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Riveting the deck plates on a ship with an automatic hammer operated by compressed air

THE SHORTAGE OF SHIPS [See page 296]

The Physiological Rôle of Calcium in Plants

A Problem of Great Importance in Agriculture

By Thérése Robert

[*Editorial Note.—The following paper is abstracted from an original thesis by Mlle. Thérése Robert, Doctor of Science and Professor at the Grenoble Lyceum, recently published in the Revue Géneral des Sciences (Paris). We omit the opening paragraphs, in which Mlle. Robert merely quotes conflicting opinions of earlier investigators of the low forms of plant life known as fungi, beginning with the author's own researchs.*]

I. THALLOPHYTES

§1. FUNGI

I HAVE undertaken afresh the study of the rôle of calcium in fungi, choosing as material the *Aspergillus niger* and the *Penicillium glaucum* and verifying the result of my experiments by chemical analysis.* My conclusions are as follows: 1. Small quantities of calcium (0.25 to 10 milligrams per 250 cubic centimeters of the nutritive liquid) introduced into a medium carefully purified from this element, occasion no improvement of growth; larger doses, (*e. g.*, 50 to 100 milligrams) produce a slight increase of weight in the *Aspergillus* but no change in the *Penicillium;* more than 1 gram of calcium becomes toxic. 2. The slight increases in weight noted when the doses of calcium approximate 100 milligrams per 250 cubic centimeters of the medium, are due to the fixation of the element under the form of the oxalate, and also to the favorable action of the sulfur when the salt added is a sulfate. In no case does the calcium by itself appear to have any activating influence on the vegetation of the fungi studied. 3. Contrary to the opinion of Osterhout, the calcium does not intervene as an antitoxic element in the culture of these fungi, when the concentration of the medium is augmented. 4. The calcium seems therefore to act as an *indifferent element* in these inferior plants.

§2. ALGAE

Loew has established by his indirect method the inutility of calcium for the inferior algae, and the necessity of this element on the contrary for the more differentiated species. Molisch, Bokorny, Benecke have arrived at the same results. This fashion of different behavior in diverse algae is of much interest. The studies of the preceding authors show that among the green algae some need calcium while others do not. This detracts from the value of the theory which attributes to calcium a role in the formation of chlorophyll.

Loew's hypothesis is that the need of calcium in algae bears a relation to the mode of reproduction. The algae multiply either by simple bipartition, by zoospores, or by ovules; in the latter case a distinction must be made between isogamy and heterogamy. According to Loew in all these diverse modes of reproduction to an increasing differentiation of the nucleus, the calcium is necessary only to forms in which the nucleus has a complex constitution.

It is interesting to recall here that certain algae, such as *Phacotus, Codium, Halimeda, Cymopodia, Corallina,* have the curious property of incrusting their tissues with calcareous matter. This is also true of the related group, the *Characea*, of the genus *Chara*. The mechanism of this fixation of calcium carbonate is still unknown. Pringsheim attempts to explain it by supposing that in consequence of the assimulation by the plant of dissolved carbonic anhydride the bicarbonate is transformed into the carbonate, which is deposited in the tissue of the plant. But this hypothesis ignores the fact that allied species behave differently.

In considering the researches upon algae a special place must be given to the important group of *Bacteria*.

Many of the synthetic nutritive liquids recommended for the culture of various species of microbes do not contain calcium; but the alimentary demands of bacteria are so slight that it is to be feared that any given medium will always contain as an impurity sufficient calcium to meet their need of this element; it is requisite, in researches upon the nutrition of bacteria to operate in media carefully purified in this respect. Sauton has undertaken under these conditions the systematic study of the mineral nutrition of the *bacillus of tuberculosis*. He has established the great importance of magnesium and potassium for this organism and the inutility of calcium.

A question which has been the subject of much research, because of its importance to agriculture, is that of the favorable influence exerted by calcic compounds (in particular lime and calcium carbonate) upon the development of the *bacteria of the soil*. Fischer explains this by a specific excitant action of the metal, but it seems more plausible to accept Dehérain's theory that this phenomenon is due to the modification of the reaction of the soil determined by the calcareous additions. These, in fact, exert their favorable action above all inacid soils

*This verification was omitted by earlier investigators.

II. MOSSES

There has been little systematic research on these plants. The study of the distribution of plants according to the nature of the soil teaches us that certain species of mosses seek calcareous earth, *i. e.*, they are *calcicoles;* while others prefer silicous territory, *i. e.*, they are *calcifuges*. Among the latter, the *Sphagnæ* are especially marked. P. Becquerel found that the two species *Atrichum undulatum* and *Hypnum velutinum* could do without calcium, or at least that in them potassium could replace calcium. Servettaz found that the moss *Hypnum purum* can live a certain length of time with very small quantities of calcium, but cannot totally dispense with it.

III. VASCULAR CRYPTOGAMS

These plants, closely related to the Phanerogams, may be regarded as having the same alimentary demands, so that our remarks on the latter will apply to the former.

IV. PHANEROGAMIA

Because of its importance this group has attracted the most study. The theoretic interest attaching to the study of nutrition in all plants is doubled here by the practical value such researches may have for agriculture. The custom of improving land by calcareous additions is extremely ancient. Such additions are especially efficaceous on granitic, schistose, or peaty land. Certain countries have been absolutely transformed by the introduction of this practice. The addition of the lime has not the furnishing of food to the plant for its sole end; its special action is the modification of the physical properties of the soil.

For about a century plaster has also been used in agriculture. The celebrated experiment of Franklin attracting attention to the good effects of calcium sulfate is well known. How shall we explain the favorable effect of this substance? Dehérain indicates that potassium sulfate produces the same results as calcium sulfate: hence it is the radical SO^4 which plays the useful rôle, and not the metal calcium. Hence the fact that farmers fertilize their land with calcic compounds, does not signify that calcium is a necessary aliment for the plant, since the lime appears to act particularly as a modifier of the physical properties of the soil, and the plaster by reason of the sulfur, it introduces, and not the calcium. Only experiments in synthetic media can instruct us concerning the rôle of calcium as an aliment for the higher plants.

The principal results of the numerous researches upon this subject may be thus classified:

1. The *distribution of the calcium* in the plant and the *form* in which it exists.
2. Proofs of the *necessity* or at least the *utility* of this element for the development of green plants.
3. *Mode of action* of the calcium; *plastic, catalytic,* and *antitoxic* rôles.
4. *Toxicity* of calcium; *calcifugous* and *calcicolous* plants.
5. *Replacement* of the calcium by other elements.

§1. DISTRIBUTION OF CALCIUM

The ashes of the seeds of most plants are poor in calcium, and have, on the contrary, a notable proportion of magnesium. The root content of mineral is of no great interest since this is an organ of transmission which saline matters in general merely traverse; however, the root is capable of fixing rather notable quantities of lime, varying from 30 to 40 per cent of the weight of the ashes.

The subterranean organs of reserve, such as tubercles, bulbs, fleshy roots contain variable proportions of calciun; but, in contrast to seeds, the weight of lime is generally higher than that of magnesia.

In herbaceous stalks the calcium content augments with the age of the plant.

The wood most often contains large quantities of lime, even up to 75 per cent of the weight of the ashes sometimes.

The bark is still richer in lime than is the wood and the proportion of this base augments with the age of the bark.

The leaves are in contrast to the seeds in their relative richness in calcium; their low content of magnesium; the proportion of calcium augments with the age of the leaf. *Albino leaves* present the interesting peculiarity of being poorer in lime than the green leaves on the same plant—a fact to which we will refer later.

If we consider the calcium content of the total plant we find that it varies both with the chemical composition of the soil and with the nature of the plant.

It may also be said in general, that in contrast to the case of phosphorus and of potassium, the proportion of fixed calcium augments with the age of the plant.

Calcium exists in the plant either in the form of soluble salts: nitrate, phosphate, sulfate, malate, tartrate, etc., or in the form of a precipitate: carbonate, oxalate, pectate, etc. This metal also exists perhaps in protoplasm under the form of organic compounds other than salts. Loew, particularly, takes this view. The two forms which have been most studied, because of the frequency of their presence in plant tissues, are the carbonate and the oxalate.

§2. NECESSITY OR UTILITY OF CALCIUM

Does the constant presence of calcium in the higher plants make it certain that this element is necessary to the life of the plant? All our knowledge tends to answer this question in the negative. The results of analytic research suggest the idea that the richness of plants in calcium is mainly due to a passive accumulation of salts of this metal, becoming more abundant as the plant increases in age. Only synthetic researches can inform us as to the degree of importance possessed by calcium as a physiologic element.

Early authorities accepted calcium as an essential element in the nutrition of plants. Stohmann, Boehm, Raumer and Kellermann, Liebenberg, concluded that calcium is necessary to the growth of phanerogams, and in particular, is favorable to germination.

Dehérain and Bréal find, however, that if the temperature is sufficiently high, the presence of calcium has no influence upon the young plant. This has been combated by Portheim, who has proved the necessity of lime, whatever the temperature. But all these researches are affected by a serious cause of error; the distilled water employed as a medium in all these experiments is not pure; usually prepared in metallic apparatus, it contains traces of copper which render it improper to use. The recognition of this fact has made necessary the revision of all experiments previously made concerning the rôle of mineral substances in germination. By employing pure water, distilled in glass only, I have been able to demonstrate that the addition to the medium of a calcium salt definitely favors the development of the young plant still living at the expense of the reserves of its seed.

§3. MODE OF ACTION OF CALCIUM

The author who has been chiefly occupied with the nature of the rôle of calcium, and that for a score of years, is Loew. He claims that organic compounds of calcium (calcium proteins) exist in the nuclei and the clorophyll bodies of green plants, playing an essential rôle in the life of the plant. The toxicity of the soluble oxalates found only in the higher plants is explained by the property possessed by these substances of destroying calcic combinations. The injurious influence of magnesium, another fact upon which Loew bases his theory, he believes due to the replacing of calcium by magnesium. According to the law of the action of masses, an excess of the calcium salt will prevent this harmful reaction; whence the specific antitoxic rôle of calcium in relation to magnesium. But this theory has been attacked by many plant physiologists. . . and it seems necessary therefore to renounce the idea that calcium plays a rôle in the constitution of the nucleus and of the chlorophyll bodies of the higher plants.

However, the fact that calcium is not indispensable in notable quantities except to these plants appears to establish that this metal really plays with them a *plastic rôle*, which is not the case with the lower plants. Numerous researches postively prove the presence of important calcic compounds in the cellular walls of green plants.

The first authors who studied the constitution of the plant membrane considered it to be formed exclusively of cellulose, but profunder researches soon proved that this substance is associated with many others in the membrane. Among these the most important seem to be the pectic compounds, including calcium pectate. This last seems to constitute a sort of cement uniting with each other the cells of soft tissues in the phanerogams and the cryptogams—the majority of the fungi and many algae excepted.

It would be interesting to verify whether the need of calcium found in so many plants coincides precisely with the existence, in the membrane, of such calcic compounds. Perhaps this would furnish the explanation of the necessity of calcium limited to a group of plants. Among other things it would aid us in understanding the different behavior of different species of algae with regard to calcium; it is, in fact, easier to believe that two closely related algae, or two fungi, differ by the constitution of their membrane than to suppose they are distinguished by the structure of the nucleus.

Mangin's researchs of the membranes of the mucorinea seem to support this hypothesis; he claims that the membrane of these fungi, like that of phanerogams, contains pectic compounds; but we know, moreover, that the presence of calcium appears to favor the development of these fungi.

Interesting researches of G. Bertrand and Mallèvre have proved that the rôle of calcium in the formation of pectic compounds is not solely plastic, but also catalytic. The appearance of pectic acid and of pectates is preceded in the plant by that of pectine; this substance, soluble in water, is transformed under the influence of a special diastase, pectase, into an insoluble substance which many authors have supposed to be pectic acid, but which is, in reality, a pectate. Bertrand and Mallèvre have shown that the presence of a calcium salt is required to permit the action of the pectase upon the pectine. But barium or strontium salts can replace calcium salts. It may here be asked whether calcium does not intervene in an analogous manner in other diastasic reactions of plants than pectic fermentation. Many authors have ascribed to calcium a rôle in the transport of starch; but this phenomenon is probably dependent upon a diastasic transformation. Several investigators have proved that there are abnormal accumulations of starch when insufficient calcium is furnished to the plant. . ., but it does not appear that in the influence of calcium on the transport of starch there is anything comparable to the rôle it plays in pectic fermentation. Its action, rather, seems indirect.

The rôle of calcium seems well established as a plastic and catalytic element in the life of the plant by what we know of the formation and constitution of the plant membrane. But it has another highly characteristic property which it exercises in animals as well as the higher plants and which may suffice to explain its utility to these organisms. We refer to the remarkable antitoxic action exerted by this metal with respect to other constituents of the medium. In plants this was first observed in regard to magnesium. Loew proposed the hypothesis to explain this in 1892. . . , but he has shown also that there is a reciprocity of action between the two elements, in that an excess of calcium, in the absence of magnesium, may also be prejudicial. He explains this by the rôle taken by magnesium in the transfer of phosphoric acid, which rôle would be prevented by an excess of calcium.

Loew deduces from this reciprocal action of calcium and magnesium in the plant that, in the substratum, the two bodies must exist in a well-determined proportion. He gives to the ratio $\frac{CaO}{MgO}$ the name of *the lime factor*. Numerous investigators, mostly inspired by Loew, have had for their object the determination of this factor, both in outdoor cultures and in artificial solid or liquid media [he announced a long list of Japanese and of Italian investigators].

An important objection to Loew's theory is that the antitoxic rôle of calcium is exerted with other metals as well as with magnesium. . . The researches of Osterhout are particularly interesting; their object is to extend to plants the results obtained by Loew with animals with reference to the antitoxic rôle of salts. According to Osterhout the concentration of salts in the nutritive solution of Knop is too weak for any one of them to be toxic when employed separately, with the exception of the salts of magnesium. But if we increase their concentration sufficiently, they become injurious, and in these conditions we can find, between calcium on the one hand and potassium, sodium, and ammonium on the other, the same antagonism as between calcium and magnesium.

I have demonstrated that on conditions of making suitable choice of material, the toxicity of potassium and of ammonium salts can be shown at the concentration at which these salts exist in the media of culture habitually employed, and that therefore the antitoxic rôle of calcium can be established, with reference to all the other constituents in these nutritive solutions.

A question which plant physiologists have asked themselves is whether calcium is necessary to the plant as a precipitant of oxalic acid or of soluble oxalates—these bodies being injurious to vegetation; or whether the plant manufactures, on the contrary, oxalic acid with the object of disembarrassing itself of an excess of lime useless to its development. In the first case the study of calcium oxalate can be connected with that of the antitoxic rôle of calcium; in the second, on the contrary, with that of the toxicity of this element. . . Physiologists have likewise sought to learn what becomes of the oxalate of calcium formed. Some consider this substance as a product of excretion deposited in the interior of the cells in a definite manner; others on the contrary, believe that it may be recovered in the metabolism, and thus play the part of a reserve substance. . . None of these questions has received an entirely satisfactory answer: there seems to be little probability that the *exclusive* rôle of calcium should be to render insoluble the oxalic acid produced by the plant, and it appears absolutely false to opine that it is the presence of the calcium which determines the formation of the oxalic acid. As to the ulterior utilization of the calcium oxalate, it is very possible that, according to the chemical conditions realized, this salt may be retaken in the metabolism or may remain indefinitely in the place where it was formed.

§4. TOXICITY OF CALCIUM

We know that all the elements may become harmful if their concentration in the medium is sufficiently high. Calcium does not escape this general law. The question is, at what point does the dose of calcium begin to be injurious to plants. All authorities show this quantity is large—hence the toxicity of calcium salts is low.

One of the first effects observed when an excess of calcium is furnished to a plant in the form of the carbonate is chlorosis of the leaves. Mazé and his pupils have proved that, in this harmful action, the calcium intervenes indirectly; in fact calcium carbonate acts by rendering the iron insoluble. However, there are plants which seem to suffer directly from the presence of an excess of calcium in the medium: these are the plants called *calcifuges* (silicicoles of the ancient botanists.)

They present the characteristic of growing on territory containing only traces of calcium, and of perishing upon a soil rich in this element. They are opposed to the *calcicoles*, plants which do not develop well except upon very calcareous land. The analysts have observed the curious fact that the calcifuges, even on land poor in lime, fix large proportions of this substance, while the calcicoles, on highly calcareous soils, often absorb only very small quantities. . . Fliche and Grandeau have taken this fact into account in their researches on two calcifuge species: the maritime pine and the chestnut.

The following figures are given in support of their conclusions; they relate to the composition of the ashes of the branches of maritime pines, some flourishing on a soil poor in lime (containing in 100 parts of fine earth 0.05 parts of lime in the soil and 0.20 in the sub-soil); the others doing poorly in territory rich in lime (containing 3.25 per cent of lime in the soil and 24.04 per cent in the sub-soil). These analyses are placed in comparison with those of a *pin laricio*, called the Austrian black pine, growing well on calcareous soil:

	Maritime pine doing well	Maritime pine doing badly	Austrian black pine
Silicic acid. .	9.18%	6.42%	7.14%
Lime.	40.20%	56.14%	49.13%

Dehérain, commenting on these results, brings out the fact that they seem to have been unexpected. He says: "It is a very curious thing that the maritime pine doing well, growing in a soil very poor in lime, should have assimilated a considerable quantity of it, little inferior to that contained in the ashes of the black pine which flourishes in calcareous soils."

Seeking an explanation for the apparently paradoxical conclusions of Fliche and Grandeau, I have been led to conclude that: 1. All green plants, whether calcicole or calcifuge—have very nearly the same *need of calcium*, since we find practically the same proportion of this element fixed by one sort or another when they are normally developed. 2. The toxic dose, producing similar injurious effects, must be also nearly the same in all cases, if we consider here agaain the quantity fixed by the plant, and not that existing in the substratum. 3. The calcifuges differ from the calcicoles solely in possessing the faculty of *fixing the calcium in larger quantity for the same proportion of this element in the medium.*

The experiments which I have made have permitted me to verify these hypotheses. They have, in fact, demonstrated that: 1. *Calcifuge plants are plants endowed with a great power of absorption in the presence of calcium.* These plants live by preference on land poor in lime, because, thanks to their great power of assimilation, they are capable of obtaining in such locations a quantity of calcium sufficient for their development; this quantity, however, being not inferior to that required by other plants. They avoid calcareous lands because the quantities of calcium which they there absorb are very considerable and attain very quickly to the toxic dose. 2. *The calcicole plants, on the contrary, are those which possess a very low power of absorption in the presence of calcium,* whence arises the necessity for them to live on land rich in lime, and also their power to live on excessively calcareous soils without suffering.

From the point of view of practical agriculture these researches show that the analysis of ashes cannot be a guide in the choice of land suitable to a given species, nor to the nature of the fertilizers demanded, for it is precisely the plants richest in lime which demand the least calcareous soils and *vice versa.* In support of this opinion we may cite the case of wheat, which will not germinate on silicious soil, yet whose ashes are very poor in calcium.

§5. REPLACEMENT OF CALCIUM

A few words remain to be said with regard to the possibility of substituting other elements for calcium. From this point of view it is particularly interesting to consider the alkaline earths. Barium being eminently toxic, by reason of its property of precipitating the sulfates and thus preventing the assimilation of sulfur, only strontium remains to be considered. But all the experiments made on this subject. . . prove not only that strontium can not replace calcium, but that in the absence of the latter substance, it becomes toxic for plants.

We have seen, however, that there exists a case in which calcium can be replaced by the other alakline earths; this is *pectic fermentation.* Nevertheless since the substitution of strontium for calcium prevents the development of the plant, there is no doubt that the latter has a rôle in the plant other than contributing to the formation of the membrane.

Is it in the antitoxic power of calcium that we must seek the origin of the specificity of its action? This seems not very probable, since at a suitable concentration the strontium also exerts a neutralizing influence upon the other toxic elements.

Another cause to which it seems plausible to attribute the non-possibility of replacing calcium by strontium is the difference in toxicity of these two metals. Experiment has proved that for analogous concentrations strontium is very sensibly more toxic than calcium. This fact bears a relation to the respective value of their atomic weights. Strontium, at 87, having a higher atomic weight than calcium at 40, is also more toxic. It is obvious that fresh research is still necessary, upon this question as upon the preceding questions.

Using the Bark of Trees

The Forest Products Laboratory experts, in their efforts to reduce the amount of waste in the lumber industry, have long declared that they have been able to utilize everything but the bark, just as the pork packer is said to market everything but the squeal of the hog.

Now they have even found a way to use the bark. By a new process, waste bark can be used to partially replace expensive rag stock in the manufacture of felt roofing, and is already being used commercially by mills cooperating with the laboratory experts. The bark thus used is that remaining after the extraction of the tannin for leather work, and the same waste bark has been used successfully for the making of a commercial wallpaper. Experiments now in progress indicate that the hemlock bark may be used for sheathing paper, carpet lining, bottle wrappers and deadening felt.—*American Forestry.*

The Thickness of the Atmosphere of Jupiter

In the *Journal* of the British Astronomical Association for November, 1916, Mr. Edwin Holmes criticises the following statement of another member of that Association:

"A planet in such a condition" (as Jupiter) "must *necessarily* have a dense and deep atmosphere."

After referring to an investigation by Mr. E. W. Maunder of the circumstances which settle the heights of planetary atmospheres, Mr. Holmes says: "We must not forget that on Jupiter gravity doubles the pressure (or halves it) every 1.6 miles. M. Flammarion calculated that if his atmosphere had a depth of only 100 kilometers, or about 63 miles, the density at 37 miles from the surface would be the density of platinum, 'and yet there are 25 more doublings of density in the remaining descent.' He adds: 'It is perfectly monstrous.' The atmosphere at the surface would be 17 millions of times more dense than platinum. I think this amounts to telling us that long before we reached even 37 miles down, the atmosphere would be compressed into a solid body and would be in no reasonable sense an atmosphere at all. And the clouds in any case under these conditions must be extremely thin, and Jupiter's beauty only skin deep."—From *Popular Astronomy*, March, 1917.

Jacoons of the jungle

A group of civilized Jacoons

Two women and two men, showing size

The Jacoons

An Aboriginal Tribe of the Malay Peninsula

By Andrew T. Sibbald

A very interesting feature in the neighborhood of Malacca is the Catholic mission to the Jacoons, a tribe of the aborigines of the Malay peninsula. Many of the Jacoons, who, according to some, are of the lowest type of the human race, build their huts in trees, often at an elevation of from twenty-five to thirty feet, and seldom of less than twenty feet. They are reached by means of ladders, up which their old men and women, their children, and even their dogs, learn to climb with ease. It is difficult for the traveler to detect the locality of these huts by any indication which the surrounding forest offers, but on a windy day he will be apprised of their vicinity by hearing strange wailing musical notes rising and falling with the breeze. These sounds are produced by long thick pieces of bamboo split between the knots, so as to resemble the chords of a harp. These they hang on the tops of the highest trees in the forest in such a manner that the wind vibrates through the chords as it sweeps by. In addition to these Aeolian harps they make out of the smaller bamboos a number of pipes, which they string together and expose so as to be sounded by the passing wind. In stormy weather the soft wailing notes of these instruments can be heard miles off.

The Jacoons are known by the Malays as *orang liar* (wild men). By this designation the Malays desire merely to specify those inhabitants of the interior who, leading a very retired and most primitive form of existence, avoid as much as possible all communication with the Malays and other more civilized people, retiring farther and farther into the jungle and mountain fastnesses as the coast people advance into the interior. These people are also known to the Malays by other names, as specifying the sort of country they inhabit; for instance, they are called *orang bukit* (hill men), *orang dalam* (men of the interior), *orang ulu* (literally, men inhabiting the sources of the different rivers) while they are more generally termed *orang utan* when they inhabit the jungles.

These people are thoroughly disinclined to improvement of any kind in their mode of life, intellectually or otherwise, although it is not occasioned by want of opportunity nor from want of brain. In appearance the aborigines are prepossessing, though it is evident at a glance that they are a low type of man. They are of exceedingly small stature, the men seldom over five feet in height. It is a rare thing for any of the *orang utan* to be converted to Islamism, or to adopt the Malay habits of life.

In disposition they are simple and amiable, sensible of and greatful for the slightest good turn or kind word; they are, however, timid to a degree that prevents their seeking intercourse with Europeans. Contented and happy among themselves, they are indifferent even to laziness, and are only forced to exertion by hunger. They live peaceably one with another, and it is seldom indeed that even an altercation ensues between them; but if any cause of dispute should arise, they do not resort to blows, but the party believing himself injured withdraws with his family and friends to another hunting-ground until a reconciliation is sought by the offender. They are like children—playful and well disposed to all, but acutely sensible of wrong or unkindness. They are thoroughly truthful and have not yet learned to lie; leading simple lives, they have little to conceal.

That these tribes are gradually becoming extinct, not only the Malays but they themselves are fully aware. The process of extinction is due mainly to the following causes: Firstly, the constant advance into the jungle of the Malay and Chinese population displaces the original occupiers of the soil, who retire into greater solitude.

Secondly, owing to frequent inter-marriages between the Malays and the *utan* women, the latter race are becoming intermixed into the former, and this mixed race is fast increasing.

These intermarriages have been in practice for centuries, and are likely to be occasioned by the flight into the interior of those of the coast Malays who preferred retirement in the jungle to embracing the doctrines of Islam at the time of the Mahometan conquest in these parts. That these aborigines believe in a God may be gathered from the accounts they themselves give of their origin; and that they believe in the immortality of the soul may be also conceded, though some of them seem to doubt as to the preservation of their individual identity, and look upon life as a mere element in creation, distinct from substance, which on death will return to a common source, to be redistributed as required. Others, again, speak of a heaven to be the reward of good men, and of a hell as a punishment for the wicked; but their religion, whatever it may be, is strongly mixed up with demonology. They believe that every man is accompanied by a good and bad angel—one leading him into danger and sickness, and another bringing him happiness and good health; but it is worthy of remark that they are much more anxious to appease and conciliate the latter than to improve acquaintance with the former; in fact, it would appear that they are rather influenced by fear than hope. It is only when on the point of death that any of them offer up prayers to God, and these are little better than the expression of a vague desire that their souls should be well cared for. They bury their dead sometimes in a sitting posture and sometimes erect, and lay beside the bodies a supply of food and some weapons, which would seem to indicate a hope in resurrection.

The mission station among the Jacoons at Malacca is about eight miles out of town; the road to it for some distance skirts the western sea beach, and is shaded by a stately double row of ansagna trees, which were planted fifty years ago, and are now in magnificent foliage, having a height of seventy and eighty feet. At two miles from town the road skirts away from the beach straight inland, and passes through country similar to that on the way to the Kassang tin mines, a long plain of paddy-fields stretching away to right and to left, till, at almost five miles from the shore, cultivation ceases, and the confines of the jungle are reached. Here, too, the road becomes choked up with underwood and tiger-grass, and is difficult of passage to a conveyance. The jungle on either side, however, is not dense, many of the larger trees have been cut down, as if an attempt at clearance had been made at one period and abandoned.

About a mile within this jungle, where the trees begin to get closer and the undergrowth denser, is the palisade of the priest's homestead. About five acres of ground had been cleared and laid out with fruit trees. The buildings of the mission comprised a chapel, a school-house and the priest's dwelling, all constructed of wood, with attap or leaf roofs, but of neat design. On the borders of the clearing are a number of huts of the natives, as many as generally constitute a Malay hamlet in the interior. Everything has an aspect of cleanliness and order, which at once impress the visitor favorably. It was on a Sabbath morning, a few years ago, that I visited this mission. We had chosen that day because the Jacoons, who were for the most part away hunting and fishing in the forests during the week, would then be gathered together in the chapel to offer up their prayers and have a sermon preached to them. The priest had just commenced his sermon when we reached the chapel, but he suspended it for a moment to come out and welcome us, and procure us seats. The service lasted for about half an hour, and the sermon for probably half that time; in the former there was not much to remark or admire, but the sermon was a good honest, simple one, delivered in Malay, and was suited even to the very limited capabilities of the hearers. There were probably 120 natives, men, women, and children, present in the church, of whom probably two-thirds were Jacoons and the rest Malays. Great must have been the labor of this lonely missionary before he assembled this crowd of worshippers, for to the Jacoons he must have had to teach Malay before he could teach them the gospel; and he must have taught all his lessons in a spirit of love and forbearance, for so timorous and gentle are these people that the slightest exhibition of harshness or unkindness would have frightened them all away.

His flock now numbered five hundred Jacoons, and they were attached to the mission by the strongest tie by which it is possible to attach their simple natures—that of affection. Here was this priest, a man of good parts and education, who had for nearly twenty years withdrawn himself from the world, built his home in the midst of these people, and devoted himself to their education and conversion, and this on a stipend of 50£ a year, which was shared by his flock.

Dried fish and rice, enriched at times by the birds or venison of the jungle brought to him by his flock, was his food, and water, with now and then a flask of old French wine, was his drink. Malacca was barely eight miles distant from the mission, and yet the priest only paid a visit to it at most at intervals of six months.

The Jacoons belonging to the mission were mostly of very diminutive stature, with wooly hair, but wearing an amiable expression upon their faces.

The three photographs represent two Jacoon men in their wild state in the interior of Malaya; and groups of Christianized Jacoon women and children taken at the Roman Catholic Mission Station near Malacca.

Modern Ideas of Cosmogony*

A Review of the Most Important Hypotheses

By Frederick C. Leonard

INTRODUCTORY STATEMENT

MODERN[1] ideas on cosmogony, or world-origin, are many. But among those extant by common consent of astronomers, these three stand out with a certain distinctive importance which merits their general acceptance as the leading representative views of to-day: the ring nebular hypothesis of Laplace, the meteoritic hypothesis of Lackyer, and the planetesimal hypothesis of Chamberlin and Moulton. A comprehensive account of these theories, *i. e.*, one including, first, a complete recital of all the facts of the universe upon which they are based, and, second, the various objections that can be raised to them, would exceed many times the bounds of a single short paper. The purpose of this article is, therefore, to review the most important features of the three hypotheses as they were originally presented. No attempt will be made to elaborate them with present-day modifications or to supplement them with comments on their probable inconsistencies with the observed phenomena of nature. Rather is there left to the reader the task of making a fair consideration of all, and of drawing his own conclusions on a subject so profound.

THE RING NEBULAR HYPOTHESIS (1796)

Of all the ideas of world-origin, the one which has created the most discussion among astronomers has indubitably been that of the great French mathematician Laplace. Although his hypothesis was considerably anticipated by the early brilliant speculations of Kant and by the cosmogonical conceptions of Swedenborg,[2] Kant's were in turn suggested by those of Thomas Wright;[3] there appears to be no evidence, however, that Laplace was ever familiar with these theories of Kant. Nothwithstanding the fact that the ring nebular hypothesis was given to the world as early as 1796, in the publication of the admirable *Exposition du Système du Monde*, yet, with some modifications which have not materially altered the original statement of the theory it has, at least until very lately, justly stood the test of time. Nor by some practical astronomers is it at the present day considered obsolete. In a recent address, Prof. Edwin B. Frost has said: "It is true that this theory of Laplace is inadequate in some respects, and is mathematically unfounded in some particulars. Its premises need modification, and it also leaves much unexplained. But no adequate substitute has been proposed, and the increased study of the different phases of development, as inferred from stellar spectra, supports the Laplacian theory surprisingly." These remarks may be taken as typical perhaps of similar views shared by a number of other contemporary astrophysicists.

Laplace commenced his discussion by pointing out that all the movements of rotation and revolution of the then known members of the solar system were effected practically in the same plane and in the same general direction, and that, moreover, the orbits described by the planets were nearly circular, while those pursued by the comets were mainly parabolic in shape. Since he had calculated that such a condition would not occur by chance more than once in five hundred million contingencies, he reasonably supposed that it was due to some factor in the evolution of the system itself. He imagined that at the time assumed to be the starting point of the development of the system,[4] there existed a vast rotating nebula, an attenuated and highly heated gaseous envelope, doubtless of greater temperature than that of the sun at present, and extending out into space beyond what is now the orbit of the farthest planet. As this enormous mass cooled and contracted, having taken first, under the influence of the mutual attractions of its parts, a roughly spherical shape, and as it diminished in bulk, by the laws of contracting bodies its motion of rotation gradually accelerated. Then as the nebula increased in its speed of rotation, it necessarily became flattened at its poles and bulged at its equator, and there probably came a time when the centrifugal force at the equatorial periphery was sufficient to overcome the gravity of the body. Thus, in the plane of its rotation, the central mass left off concentric nebulous rings,[5] one after another, at the respective distances from its nucleus at which the planets are now situated from the sun. In time, the matter composing the rings disintegrated and ultimately it coalesced into globes, so producing the planetary masses. Likewise these masses abandoned rings which furnished them with an accompaniment of satellites. Finally, the central nucleus and the planetary and secondary nuclei, after a long-continued process of cooling, contraction and rotation, developed successively into the sun, the planets and their satellites, the first by reason of its supereminent bulk, remaining incandescent long after the lesser orbs had cooled or grown even entirely cold, *e. g.*, like our moon.

*Republished from *Popular Astronomy*.

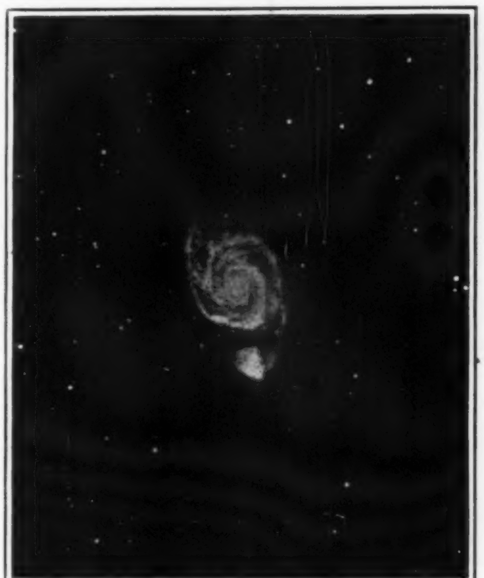
[1]By "modern" is meant theories current since the middle of the eighteenth century.

[2]Set forth in his *Principia* (published 1734).

[3]Regarding the evolution and construction of the entire sidereal universe (published 1750).

[4]Though by no means the beginning of the *matter* composing it.

[5]These rings would no doubt be similar in appearance to those of Saturn which, in fact, were probably what suggested this feature of the theory to Laplace.



Spiral Nebula, M 51 Canum Venaticorum

Photographed with Two-foot Reflector of Yerkes Observatory By G. W. Ritchey, 1902

From the *Astrophysical Journal*, Vol. XXII

Though it is not necessary to enter here into a criticism of any of the details of the ring nebular hypothesis, obviously difficult as many of them are to reconcile to conditions actually existent in the solar system, it is seen that, according to it, out of a chaotic gaseous envelope were thus evolved in turn, the planets, and the satellites. How their development came about will now be considered as it is explained by the meteoritic theory.

THE METEORITIC HYPOTHESIS (1890)

What may be regarded as a modification of Laplace's view, principally in that the matter composing the original solar nebula is assumed to have been of *meteoric* constitution rather than of *gaseous*, is the meteoritic hypothesis of Sir J. Norman Lockyer. This idea, which has gained considerable prominence, but which Lockyer has told us was by no means first propounded by himself, will nevertheless always be inevitably accredited to him, both because of his acceptance of the view and the vindication that he has received for it from elaborate experimental researches on the spectra of meteorites under varying states of incandescence.

Lockyer claims to have discovered in the laboratory spectra of meteorites a certain correspondence to those of all the spectral types of stars, of nebulæ and of comets, and even to the spectra of such phenomena as the auroræ and the zodiacal light. He believes that this marked similarity has important relations to the question of cosmic evolution. But in order to understand his point of view, it will be well to know his definition of a nebula which he gives in these terms:[6]

"A true nebula consists of a sparse swarm of meteorite the luminosity of which is due to the heat produced by collisions. The interspaces are partly filled with hydrogen and magnesium and other vapors, which are volatilized out of the meteorites. Amongst true nebulæ, are the great nebula in Orion, that surrounding η Argûs, the ring nebula in Lyra, and all planetary nebula." Upon this assumption, he argues that as the aggregation of the particles in nebulæ continues, they evolve into stars by ordinary condensation and accretion, and that as these stars pass through their long complicated life-cycles, the temperatures of the bodies gradually attain a maximum and then decline so that the stars are ultimately reduced to non-luminosity. He further presumes that each successive period in this evolution is duly marked by its corresponding typical spectrum.

[6]*Elementary Lessons in Astronomy*, p. 42.

Sir George H. Darwin has demonstrated mathematically that a meteoric swarm of the dimensions and mass of the solar system, consisting of individual particles of the sizes of meteorites that fall to the earth, and endued with velocities equal to the known velocities of meteors, would, if observed from interstellar distances, show no phenomena differing perceptibly from those of a mass of continuous gas; and that, if the swarm were dissipated sufficiently, it would rotate like a solid. Under the kinetic theory of gases, however, such deductions are to be expected, because, according to it, a gas is itself an immense collection of molecules moving similarly to the way the meteorites are conceived to move in the meteoritic hypothesis. But Professor Young maintains that "it follows that the *meteoric* theory of a nebula does not in the least invalidate, or even to any great extent modify, the reasoning of Laplace in respect to the development of suns and systems from a *gaseous* nebula." Hence, Lockyer's theory, as applied to the solar system, is dynamically identical with Laplace's.

The hypothesis of Lockyer explains all the evolutionary phenomena of the heavenly bodies entirely on the basis of differences in temperature. His whole theory may therefore be well summed up by his own words on p. 247 of *Elementary Lessons in Astronomy:* "We begin with sparse swarms of meteorites at low temperatures, pass through the various phenomena of increasing temperatures to stars like Vega, then through those of decreasing temperatures, finally ending with cold, condensed and consolidated masses. Further, it is possible that bodies of the latter kind may collide as individual meteorites do, and by such collisions become again resolved into swarms of meteorites, *and thus complete the celestial cycle*."[7] It is interesting to note, both in Lockyer's hypothesis and in the one about to be reviewed, the distinct tendency toward a possible cyclical explication of the evolution of stars and systems.

THE PLANETESIMAL HYPOTHESIS (1900)

The first published account of the planetesimal hypothesis was presented by Prof. T. C. Chamberlin in a paper in *Year Book No. 3 of the Carnegie Institution of Washington*, entitled *Fundamental Problems of Geology;* another exposition of the same theory, by Prof. F. R. Moulton, the co-author, with Professor Chamberlin, of the hypothesis, has since appeared in the *Astrophysical Journal* for October, 1905, *On the Evolution of the Solar System*. The following extract is taken from the latter paper: "It is supposed that our system has developed from a spiral nebula, perhaps something like those spiral nebulæ which Keeler showed are many times more numerous than all other kinds together. The spiral nebula is supposed to have originated at a time when another sun passed very near our sun. The dimensions of the nebula were maintained almost entirely by the orbital motions of the great number of small masses of which it was composed, and only a very little by gaseous expansion. It was never in a state of hydrodynamical equilibrium, and the loss of heat was not necessary for its development into planetary masses. The planets have been formed around primitive nuclei of considerable dimensions by the accretion of the vast amount of scattered material which was spread throughout the system." In his *Introduction to Astronomy*, p. 464, Professor Moulton writes, "Because of the fact that every particle is supposed to have moved nearly independently like a planet, Chamberlin calls the theory the *Planetesimal Hypothesis*."

Not long prior to his death in 1900, Prof. James Edward Keeler, director of the Lick Observatory (1898-1900), made an extended photographic investigation of nebulous regions in the heavens. From his photographs he was led to the general conviction that the spiral nebula (one of the most beautiful representatives of which is herewith reproduced), belongs to the usual and predominating class of nebula. He stated that at a conservative estimate there were probably as many as one hundred and twenty thousand such objects accessible to the 3-foot Crossley Reflector of the Lick Observatory. He further called attention to the remarkable fact that "Most of these nebulæ have a spiral structure," and stated that "While I must leave to others an estimate of the importance of

[7]The italics here are mine.

these conclusions, it seems to me that they have a very direct bearing on many, if not all, questions concerning the cosmogony. If, for example, the spiral is the form normally assumed by a contracting nebulous mass, the idea at once suggests itself that the solar system has been evolved from a spiral nebula, while the photographs show that the spiral is not, as a rule, characterized by the simplicity attributed to the contracting mass in the nebular [Laplacian] hypothesis. This is a question which has already been taken up by Chamberlin and Moulton of the University of Chicago." From a spiral nebula, similar, though undoubtedly far inferior to that transcendent mass delineated in the accompanying photograph, according to the planetesimal theory, the solar system has been evolved. We shall now trace briefly the various essential steps of the hypothesis.

It is reasonable to imagine that, in the passage of one sun, or star, through space, it may at some period in its course pass near to, or very infrequently, actually collide with, another sun.[8] When two large cosmical bodies come within proximity of each other, they are subject to violent tidal strains, which are due to their mutual attractions. As one star, S', approaches another S, it will follow therefore that an immense tide will be produced on the side of *S toward S'*, and one almost equally as great, on the *opposite* side of S, and that matter will continually be erupted by S in the direction of S'.[9] Now as S' continues to move, its line of motion will be deflected from the original course on account of the gravitative attraction of S, so that S' will be compelled to describe a parabolic or an hyperbolic curve around S. As S' moves in this curve, it will drag the ejected material of S around in the direction of the motion, instead of allowing the eruptions to precipitate themselves back upon S, as they normally would, if not affected by any exterior forces, until S will, before long, have the appearance of a huge spiral with two great arms coiled around from two diametrically opposite points on the central nucleus.

Concerning the present appearance of the spiral nubelæ, Professor Moulton writes:[10] "When we see a spiral nebula we do not see the paths which the separate masses have described, but the positions which they occupy at the time. . . . if a smooth curve is drawn through the regions where the matter is densest, it will form a sort of double spiral. . . . "There will be nuclei here and there along the arms of the spiral where large masses have been ejected, and the whole space will be more or less filled with finely divided and nebulous material. It must be remembered that *the matter does not move along the arms of the spiral, but* in orbits which cross them at right angles. The particles in the smaller orbits will move faster than the outer ones, and the spiral will become more and more coiled with age until its spiral character can no longer be discerned. In the photographs of spiral nebulæ the *two arms* can nearly always be easily made out, and it is significant that no other number is certainly found. But it is almost certain that the spiral nebulæ which have been photographed are much greater than the one from which our system may have developed."

To account now for the planets, the satellites, and the sun, from the primitive spiral: It is assumed that the planets have developed from the larger nuclei scattered throughout the nebula, which were increased in volume by the gradual accretion of the smaller masses whose orbits intersected or passed near to theirs. The major planets can easily be explained on the possibility that their paths lay in regions of the nebula where the material was densest, and the asteroids as simply the lesser nuclei not in those parts of the spiral in which the matter was swept up by the greater globes of the system. As these large masses left the Sun S, they were accompanied by multitudes of smaller secondary masses. If their velocities became too great, these bodies escaped from the gravitative control of their primaries. If, on the other hand, the velocities were too feeble, the masses were absorbed by the superior globes and so lost their individuality. But if the rates of motion could not overcome that attraction entirely, yet were strong enough to resist it sufficiently, the secondary bodies were forced to remain as satellites circling about the planetary nuclei. Our present sun is merely the ultimate result of the development of the central nucleus of the spiral, which originally was the star S in the hypothesis.

The subsequent physical conditions of the several planets, as explained by the planetesimal theory, are especially interesting to trace, but are best described by Professor Moulton himself:[11] "The evolutions of the small and large planetary nuclei have been quite different. They were all very hot at the time of their ejection. The small nuclei did not have sufficient gravitative control to retain their lighter gases. In a comparatively short time they had no appreciable atmospheres, and they speedily cooled until they became solid. The meteroic matter which fell in upon them was also in a solid state. The relative velocity was in general so small that no great amount of heat was generated by the impact, and what was produced speedily radiated away. After the masses began to assume earth-like dimensions the interior pressure became very great and they diminished in volume. This shrinking produced *interior* heat just as it does in the case of the sun. . . .

"The earth acquired its atmosphere chiefly after it became about as large as Mercury. The atmospheric gases came from the interior squeezed, as it were, out of the heated and compressed material. Bodies much smaller than Mercury have never retained any real atmospheres. This applies to most of the satellites and to all of the planetoids.

"On the other hand, the large planetary nuclei were so massive that they never lost their light gaseous envelopes. Because of this their original heat was largely retained, and they have not yet contracted to any great extent. They are less dense than the smaller planets both because they retained nearly all of the original light elements, and also because the conditions have been unfavorable to their cooling and contracting."

There is a decided hint in the last two paragraphs of the foregoing quotation respecting what planets of the solar system might best be considered as possible abodes for life not entirely dissimilar to that with which we are familiar on earth; especially do the comments about what planets could and could not retain an atmosphere concern this point. A discussion of the subject would, however, lead far beyond the limits of the present paper into the sphere of interesting, but endless speculation.

CONCLUSION

It were redundant to call further attention to the striking departure of the planetesimal theory of Chamberlin and Moulton, both from the time-honored ring nebular hypothesis of Laplace, and from Lockyer's modification of Laplace's idea. Whether the later view will succeed entirely in supplanting the earlier theories is still a pregnant matter for conjecture and revelation, and one certainly of great interest to astronomers.[12] That each of these hypotheses has in its turn been an epoch-making contribution to the sublimely theoretical and philosophical departments of astronomical science may aptly be affirmed. The following and concluding paragraph of Professor Moulton's paper *On the Evolution of the Solar System* well illustrates the general trend in cosmologies to-day:

"The spiral theory is fertile in suggesting new considerations for interpreting the immense variety of special phenomena of the system. It is not too much to expect that it may suggest new questions for observational investigation. It affords geologists new conceptions of the early history of the earth. But perhaps its most interesting contribution is to our general philosophy of nature. Heretofore, we have regarded the cosmical processes as forever aggregating matter into larger and still larger bodies, and dissipating energy more and more uniformly. Now we recognize important tendencies for the dispersion of matter. This idea has introduced an element of possible cyclical character in the evolution of the heavenly bodies, though the question of the source of the requisite energy is serious. There is hope that the difficulties of this question may soon be relieved, for recent discoveries respecting the internal energies af atoms suggest the possibility that the Helmholtzian contraction theory explains the origin of only a part of the energy given up by the stars."

[8] As a matter of fact, it has been computed that a near approach does really happen to a star on the average of once in a billion years.

[9] This matter would resemble the eruptive prominences on the sun, only it would be on an enormously greater scale than they are.

[10] *Introduction to Astronomy*, pp. 469-70.

[11] *Introduction to Astronomy*, pp. 484-5.

[12] The planetesimal hypothesis may be correct, even though the suggested origin of the spiral nebulæ is false. Professor Moulton has stated (*Introduction to Astronomy*, pp. 465-6): "The theory of the evolution of the system from a spiral nebula is largely independent of any hypothesis about the origin of the spiral. However, a possible, and even probable, mode of generation of these remarkable forms has been suggested by Chamberlin; and for the sake of having a definite theory to work on, it will be assumed, at least provisionally, that the solar spiral nebula was developed in this way."

Astronomy and the End of the War*

UNDER this head was published in the March number of the *Revue du Ciel* the following article, contributed by a subscriber to that periodical:

"In reading the *Corriere della Sera* I notice a prophecy relative to the duration of the present war and which has to do with the beautiful science of Astronomy. It is the Chevalier Monti, director of the Civic Museum at Como who possesses the text of it, or at least the copy from a manuscript of the seventeenth century. The *Revue du Touring-Club* of Italy has furnished, it seems, a photographic facsimile of this curious bit, whose author is no other than he to whom is attributed the famous prediction called that of Saint Malachi, who under the form of symbolic devices and emblems has characterized the reign of different Popes.

"Although it is demonstrated to-day that the prophet in question lived in the fifteenth or sixteenth century, whereas Saint Malachi died in the middle of the twelfth, the two predictions are none the less interesting. Here is the translation of the passage relative to the present war:

"When the first number shall meet the ninth and when they two shall be united with the first and the sixth (1916), during the sixth month of the year (August according to the old calendar) and after two times four and two times ten days shall have passed (August 28th), the new races which draw their name from Romulus (Roumania) shall rise and shall ally themselves with powerful nations. Then the fierce beast who for two years and one month (exact date of the beginning of the war) has been filling all the earth with blood, with horror, and with carnage, now surrounded, smitten from all sides and roaring in vain, will seek whom he may devour but shall not find him. There shall be new battles while new moons shall wax and wane thirteen times. The fifth day after the sun leaves the sign of the Lion, the beast shall die of a fearful death. A virgin whose name contains two iotas, two alphas, a tau and a lambda (Italia) shall crush his head and the latin peoples shall share his spoils.'

"A good half of the prediction, remarks the *Corriere della Sera* is already accomplished; we shall see if the remainder will conform to the beginning.

"Let us leave to the astronomers the task of clearing up the computation of the moons.

"It seems at first sight that the problem does not exceed my astronomical knowledge; it is for that reason that I take the liberty of sending you the reflections which this prophecy has inspired in me.

"The 28th of August, 1916, was new moon, and the thirteenth thereafter falls on August 17th, 1917. So when thirteen new moons have set, we shall be at the 17th of August of this year. The war would end then in the moon which extends from the 17th of August to the 16th of September, 1917. At what date? That point the second part of the prophecy determines.

"The sun this year leaves the sign of the Lion on August 23d; the fifth day thereafter brings us to the 28th of the same month. That is, according to the author, the day which is to mark the end of the war and it is at least curious to note that a scholar living three or four centuries ago, has been able thus to determine the two astronomical circumstances. Events will tell us whether the prophet was right and whether really the present war will come to an end on the 28th of August of this year."

*Translated from the French by Professor J. P. Bird, Carleton College. Republished from *Popular Astronomy*.

Agar-Agar in Treating War Wounds

EVER since the beginning of the war, the most approved practice was to keep antiseptic solutions as long as possible in contact with infected wounds so as to bring about their disinfection in the best manner. Drs. Loeper and Barbarin have brought out a new treatment which has some advantages, especially in keeping the edges of the wound open, and in ease of working. Dr. Carrel employs a spongy material placed in the wound, but the authors substitute small sachets of gauze of various shapes and sizes containing agar-agar. This substance comes from Japan, Ceylon and Java, where it is prepared from certain sea weeds which are usually the *Gracilaria*, *Euchema* or *Gelidum*. It usually comes in thin and flat semi-transparent pieces or strips, but more recently it has been obtained in flakes. The authors use it in this latter form. Being of a mucilaginous nature, it swells up in water and absorbs about eight times its weight. Some of the water can then be pressed out, for instance two-thirds, and the rest is retained by the flakes whose volume is about tripled. Being thus an elastic substance which can be dilated and compressed, and retaining liquids very well, it possesses the qualities which are lacking in substances which are usually employed for wound treatment. Again, from its chemical character, it gives a good backing for usual antiseptics, for it only fixes an insignificant quantity of active principles. The authors make up small flat bags or sachets of gauze of rectangular shape filled with the substance for use on the surface of the body, or in other cases very small gauze bags either with or without a drain and which are about the size of a plum when in size, for instance when used in deep wounds. The bags containing the flakes can be sterilized in a closed boiler, but it is preferable to sterilize by dry heat. The authors have already applied this method to a great number of wounds, with excellent results, and in all cases the wound healed up very rapidly after an antiseptic treatment which was often of comparatively short duration.

The Marseilles-Rhone Canal

One of the most important pieces of engineering enterprises in modern times is the construction of the great canal between Marseilles, the busy seaport on the Mediterranean which is the commercial metropolis of France, and the lower Rhône, or "great Rhône," which begins at Arles, lying at the head of the river's delta.

Marseilles, the "gateway of the Orient" is the logical link of commercial connection between the over-seas products which crowd her wharves and those of the busy manufacturing centers of western and norther Europe accessible to the navigable Rhône. But though river and city are comparatively near each other as the crow flies, they are separated by natural obstacles which have hitherto proven insuperable. On the one hand the treacherous waters of the Gulf of Lyons, with its dangerous depths, its inhospitable shores, and the violent winds which, rushing down from the Cévennes mountains, whip its waves to sudden fury; on the other the various difficulties which the conformation of the land opposes to traffic, including the Crau desert, the Berre Lake and the mountainous projection of l'Etoile, running west to east from the Gulf of Fos to l'Huveaune.

Though the public utility of a water-way which could overcome these obstacles to traffic has been clearly perceived for something like a century, the decree under which the present canal was begun was not finally signed until December 22, 1903, the great railway expansion in the middle of the eighteenth century being one of the factors in the delay. The work is expected to be concluded in 1919 and to cover a total length of 82 kilometers between its extreme points, Marseilles basin of the Madrague and the "Bras-Mort" of Arles.

The early promoters of the canal projected no less than twenty-four locks but as it is now being built it has none, being at sea level throughout its course. There are, indeed, ports along it, at Marignane and Port-de-Bouc; but here we have merely equilibrium locks, designed to prevent the formation of currents. At Arles alone is there a real lock, putting the Arles Canal at Bouc in communication with the Rhône, and designed to compensate the difference of level between river and sea, which is about 1.75 meters.

The normal section of the canal will be 2.5 meters wide between the banks, and the depth of water between Arles and Port-de-Bouc will be normally about 2.5 meters, but may later be deepened to 3 meters. This depth of 3 meters has been already adopted for the Marseilles-Bouc section, since this part of the route will be frequented by barges drawing 2.5 meters of water.

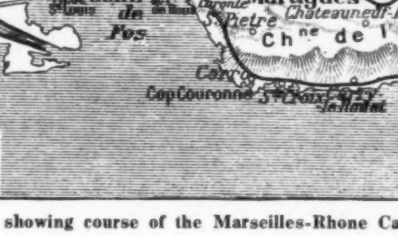
Important structures connected with the canal are the cut of the Ulède, that of Gignac, which is 2 kilometers long and 30 meters deep and crossed by the two bridges of the Toës and of the Floride, and the Rove tunnel, the most important work connected with the future water-way. This is said by *Larousse Mensuel*, (Paris), to which we are indebted for the details in this article, to be not only the longest work of this kind ever executed upon French soil, but to be wider than any other in the world, its width of 22 meters (71.5 feet) being unique.

The immense amount of labor involved in such an enterprise can be realized by a glance at the following figures. From the bottom of the canal to the top of the vault the height of the Rove tunnel is 14.4 meters, which gives a section of 300 square meters, equal to *six times* that of an ordinary double track *railroad* tunnel. The debris to be extracted amounts to 2,200,000 cubic meters, or twice as much as that of the *double* tunnel of the Simplon Pass, which, with its 20 kilometers of length, still holds the record of being the longest in the world.

These dimensions of the Rove tunnel render possible the passage not only of the barges used in navigating the Rhône, but also of two sea-barges, each drawing 2.75 meters of water, capable of carrying 900 tons and moving in opposite directions. The excavation of such a tunnel, capable of holding eight tunnels as big as that of the Metropolitan Underground of Paris, has not been finished yet. The opening was commenced April, 1911, and completed in February, 1916. Many difficulties have been encountered; to mention only those belonging to the *terrain* itself, there was just that of the Dolomitic territory with its pockets of sand; then, in the solid rock, that of pockets of clay containing volumes of water; next, soft calcareous schist; finally, beds of clay hard to cut through and ledges of puddingstone much harder to extract because mingled with softer portions. Three years more will be required to finish the Rove tunnel.

Owing to the unforseen difficulties created by the war, the expense of the undertaking will much exceed the estimated figures. The estimated expense of 91,400,000 francs, (about $18,280,000,) of which the Rove tunnel claimed 55,600,000 francs, (about $11,120,000) is expected now to exceed a hundred million francs ($20,000,000).

Map showing course of the Marseilles-Rhone Canal



Cross section of the Rove Tunnel
The two benches BB, two meters wide, carry the tracks for the hauling locomotive

This expense is distributed among the Government, the Department of Bouches-du-Rhône, and the City and the Chamber of Commerce of Marseilles. The benefits expected from this vast expenditure are manifold. First, the prevention drainage to the low land adjacent to the canal; second, the continuity of communication between the great seaport of Marseilles and the ports of the Rhône. But there is another advantage which looms large in these days of conflict. This will be best understood by a glance at the accompanying map of the region.

The fine interior body of water known as the Lake or Pond of Berre, 22 kilometers long, 6 to 14 kilometers wide, with a shore line of 72 kilometers, forms, together with the similar body, Lake Caronte, an immense natural basin capable of holding the military and commercial fleets of France secure from all hostile attack. On May 7, 1916, at the Rove tunnel celebration, the president of the Chamber of Commerce of Marseilles said, "We regard this magnificent domain as the extension and complement of the ports of Marseilles and forming a unit with them." Industrial establishments of all kinds have in fact sprung up on the shores of the Berre Lake since the beginning of the war. Obviously, as soon as the great canal is finished they will have the advantages of cheap freight rates to the great sea-port, and thence to the Mediterranean with its facilities for reaching all parts of the globe.

This canal, indeed, prolonged by the Rhône and then by the Saône, completes a continuous waterway of 540 kilometers length navigable by barges capable of carrying 600 tons of freight. Smaller boats will extend this freight route by means of the Saône Canal and those of the basin of the Seine even to Havre and to the extreme north of France. Thus, say enthusiasts, in 1919 the North Sea and the English Channel will be united with the Mediterranean by an unbroken aquatic ribbon, and France will reaffirm her claim to being a natural roadway between the nations. If this dream be too iridescent it can not be doubted at least that the great canal will immensely stimulate the traffic of merchandise in Marseilles, which had grown from 4,372,000 tons in 1870 to more than 21,090,000 tons in 1913.

Standard Flour and Bread in Europe

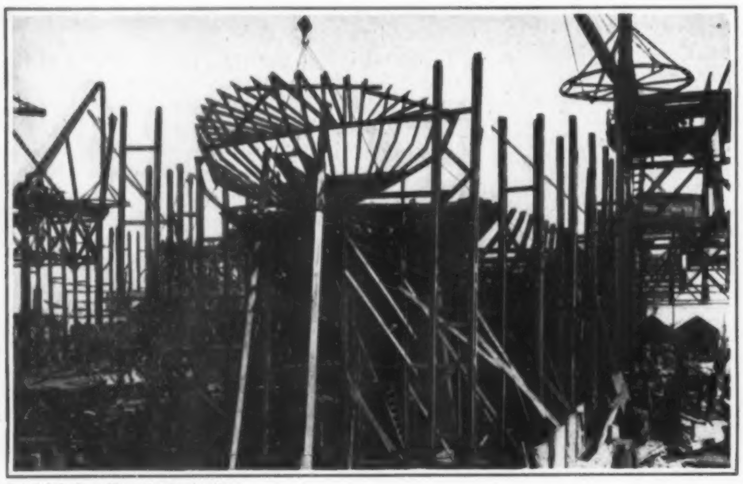
Scientists who are occupied with food questions appear to have been unanimous in condemning the use of fine bolted or over-white flour, because it has long been recognized that the bolting process takes out some of the most nutritious elements of the wheat. Numerous articles have appeared in the scientific press upon this subject, recommending the use of a less bolted flour even though the bread may not have as attractive an appearance, for in fact, we thus lose a great nutritive value which is of course to be deplored, and this simply in order to obtain an attractive whiteness in the bread.

It is interesting to note that war conditions are acting in a rather unexpected way to produce the results which scientists formerly demanded in vain. In fact, a number of European governments have already laid down rules for a standard bread in which the valuable food constituents shall not be removed from the flour. This measure is of course dictated by economy of material, that is, a greater weight output from wheat than was heretofore obtained, but at the same time the new regulations serve indirectly to retain what were long ago recognized as valuable food constituents. For instance, the new British regulations call for a standard flour known as "straight-run," and it is of course, less finely bolted.

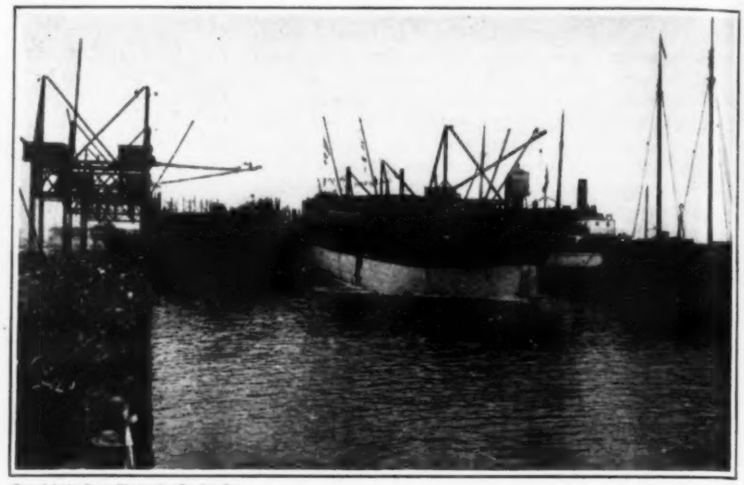
The proportion of constituents in flour varies in the first place with the variety of the wheat and second according to the milling processes, especially that of bolting. These latter processes vary considerably in different countries, and even a small flour mill is equipped nowadays to produce different grades, for the demand for a whiter flour has been more and more exacting. But under the new conditions for standard flour it will be impossible to procure the more expensive grades, while on the other hand the poorest consumer will be protected from anything of a really inferior value. The new flour is as neutral as possible as to aperient and astringent qualities, and even though it is not so white, this consideration must of course be excluded under the present circumstances.

Canadian wheat, which makes for a shapely loaf, is to be a strong ingredient, and it is stated in the London daily press that the government also engaged to take 2,000,000 tons of Australian wheat, which is of a pale golden color, the most beautiful color, in fact, of all wheat in the trade. As regards France, this country is now using a standard bread on about the same lines that we have just mentioned, and it is expected to secure a considerable economy of wheat in this way. Switzerland long ago recognized the advantages of using standard flour, and the white bread rolls which were supplied in every Swiss village are no longer seen, because not long after the war the authorities made rules for standard bread. This is now of a pale brown color and is no doubt much more nourishing than the former qualities.

White flour of the fine grades has now disappeared completely, in this country, as the mills no longer produce it.



Hoisting the completely framed transom into place



Launching the finished hull from the building ways

The Shortage of Ships

What is Being Done in America to Meet the Situation

For more than three years millions of men, of the armies of Europe, have been consuming about every material that the world produces, and their demands have not only exhausted the home accumulations but practically all of the surplus of other countries. The demand has, however, not ceased, but is daily becoming more strenuous, especially in the way of food, and the resources of the entire world are being taxed, not only to supply food for home consumption, but for the excess of material that the European countries cannot produce for themselves; and in this demand are involved not only the countries actively engaged in the war, but Norway, Sweden, Holland, Denmark, in fact all of the so-called neutral nations of Europe.

To transport the great bulk of material needed by Europe, from distant, overseas countries which can spare the supplies, requires many ships, and indeed, the entire tonnage of the world of 1914 could be kept busy by the transportation demands of today. The emergency, however, finds the mercantile fleet depleted from every side, for recklessly strewn mines and an indiscriminate use of submarines has not only decimated the merchant marine of the Allies, but has made serious inroads on the fleets of the United States and of all neutral countries as well. How serious this is may be judged by the fact that it is reported that up to April, German submarines had sunk 410 Norwegian vessels, 111 Swedish, 61 Dutch, 50 Greek, 33 Spanish vessels, besides 19 American. Besides these losses the governments actively engaged in the war have been obliged to commandeer a large percentage of their merchant shipping for military purposes, and have taken over a large tonnage under construction in their home yards to supply losses.

To make up the shortage, as well as to replace other losses still to come, has placed an unprecedented strain on the shipyards of the world, and the principal reliance in this emergency is the United States, for it is not alone a question of builders, but largely of supplies of material, particularly steel, of which this country is such a large producer. Of the European countries, those that produce any material quantities of iron and steel need the greater part for other purposes than ships; and although England, France and Italy are turning out a large number of ships, most of these are required for military and naval purposes, leaving but a small surplus for the important work of carrying food and other supplies. Japan is building a few new ships, but the number is necessarily limited by the amount of steel that it can secure.

In the United States our ship builders have been extremely busy for several years turning out vessels, but even here the yards have not been able to operate at their full capacity because of the difficulty in obtaining the necessary quantity of steel. These yards have, however, been greatly enlarged since the commencement of the war, and are capable of still greater extensions if they could get the building material to use.

In this emergency our builders have turned to wooden vessels, and not only have a large number of new establishments of this kind been opened on the Pacific coast, where the building of wooden ships has been carried on regularly, and mostly for local use, because of the abundant supplies of suitable material near at hand, but many of the abandoned yards of New England have been re-opened. On the South Atlantic coast also a number of yards for building wooden ships have been opened, and all are busy. Statistics of building show that on January 1st, 1917, there were under construction, or under contract, 161 wooden vessels of 207,623 gross tons, nothing under 500 tons being included. A large proportion of these are to be supplied with power, mostly with internal combustion motors, but on account of inability to secure engines promptly some of these vessels are being so constructed that motors can be installed later, when available.

On January 1st there were on contract in American yards vessels of an aggregate tonnage of over 1,700,000 tons, including the above wooden vessels, but exclusive of those building for the navy, of which it is estimated 60 per cent are on order for foreign owners. Among these foreign owners Norway has been heavily represented, but of late many large contracts have been received from England, which is figuring not only on present necessities, but future requirements after the war. That so small a proportion of the great tonnage being turned out from our American yards is for American owners is to be seriously regretted by every patriotic citizen, but it is easily explained by the burdens and restrictions that have been imposed on American-owned shipping by Congress, which has for years made this branch of our commercial activities a target for adverse legislation, as a result of the activities of labor unions, and, it has been strongly hinted, the influence of foreign countries that have greatly profited by our official neglect of our shipping.

To meet the pressing necessity for sea transportation Congress has created a Shipping Board, under which a corporation is to be formed with a capital of \$50,000,000, with the Government as the sole stockholder; and this vast sum is to be expended in building a fleet of wooden ships. It is estimated that a wooden vessel of 3,000 tons can be completed in from five to seven months, and that by October next we will be turning out vessels of this size at the rate of 200,000 tons a month. It is proposed to build a thousand of such vessels, all of which are to be provided with power sufficient to give them a speed of ten knots under ordinary conditions, but capable of twelve knots in war zones, and it is expected that nearly the entire fleet can be built and equipped in about sixteen months.

This is a meritorious proposition as far as the present is concerned; but a particularly unpleasant feature of the proceeding is that at the end of the war America will be left with a great fleet of inferior wooden vessels, while every foreign country will be equipped with first class steel vessels, with which the makeshift wooden craft cannot hope to compete in the carrying trade of the world. Of necessity these wooden vessels must be constructed of green timber, direct from the forests, and although the promoters of the scheme figure that they will last from twenty-five to thirty years, it is more than probable that no such period of service could be had from them without extensive renewals and repairs. A far wiser plan would be for our Government to commandeer all the steel ships building, and to be built in our yards until the end of the war, and compel foreigners to take the wooden vessels.

In connection with the rapid production of ships a movement is being agitated in England for standardization in shipbuilding. As far as the plan regards sizes and models it is difficult to see any great success; but the main feature of advantage would be in a standardizing of the materials employed. At present, in England, there are three associations that regulate the rating of ships, and upon these ratings insurance is based—an important point with owners, and each of these associations has its own specifications for sizes of frames, beams, plates, etc. If these associations can get together, and formulate uniform specifications the steel manufacturers could produce standard sizes of materials in quantities, and keep them in stock with the certainty that they will be readily salable, thus avoiding the present necessity of making each lot to order. This standardization would also facilitate the work of the builder in many ways. Another direction in which standardization can be successfully applied is in engines and boilers, for a few sizes of uniform and simple design could easily be formulated that would fit the requirements of 90 per cent of mercantile craft, and this would make quantity production possible, with a great saving of time and expense.

One important point that has apparently been given but little attention in this country, but which has been carefully considered by British builders and owners, is the question of speed. The argument of these people is that a slow cargo carrier is dangerously vulnerable in submarine zones in time of war, and consequently it is desirable to build craft that are fast enough to escape the average underwater boat. Moreover, during the critical commercial period immediately following the war, fairly fast cargo carriers will be of immense value in assuring the supremacy of the British carrying trade. It is also pointed out that some of the larger vessels of this type, while used for cargo carrying during the war, can be readily altered for passenger service later on. It may be pointed out that many of the big ore-carrying vessels on our great lakes have a speed of fifteen, or even sixteen miles an hour; and while these speeds are desirable in that region where the open season for navigation is limited, still there seem to be good reasons for believing that higher speeds in seagoing cargo carriers than have heretofore been customary are commercially practical.

Before closing reference may be made to the situation of Germany in relation to commerce carrying. The statement is made that Germany has lost so far more than sixty per cent of her merchant ships through mines, torpedoes and seizure, amounting approximately 2,259,000 tons, and should Argentina and other Latin American countries take possession of the German vessels in their ports this total will be increased by 676,000 tons. Other figures place the total loss to Germany at about 3,600,000 tons, including ships now in neutral harbors, as against 2,419,000 tons that are safe in home ports. To meet these losses we have been told of strenuous activities in the German shipbuilding yards, where many vessels ranging from 15,000 to 35,000 tons are said to be nearing completion; but well informed people claim that, while this great amount of building is projected, little or nothing has as yet been accomplished, and there are apparently good grounds for this claim in view of the well known shortage of material, which can hardly be spared for ships at this time, and the further lack of sufficient labor for the work.

If America is to have a serviceable and competent merchant marine after the war, and not be left with a fleet of obsolete wooden vessels plans to that end should

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The mold loft where patterns for every part are laid out

Copyright by Press Illustrating Service, Inc.
Great shed where the steel plates are shaped and punched

Copyright by Press Illustrating Service, Inc.
The keel and floor framing of a steel ship

Another view showing construction of the bottom of a ship

be formulated at once, and all available funds expended with that object in view; and in this connection we must not lose sight of the fact that big shipbuilding yards are now being established in Canada that will compete not only with the important American establishments on the great lakes, but with every other yard in this country.

Prehistoric Ruins of the Mesa Verde National Park*

After a brief introduction on the situation and physical features of the Park and a short account of archeological work already accomplished, the speaker described in detail the uncovering and repair of one of the large pueblo-like buildings of the Mummy Lake group, situated on the government road, 4½ miles from the ruin known as Spruce-tree House.

The mound excavated is one of the largest of the group, and when the work began gave no indication of the form, size and architectural features of the building it covered. After three months' work there was brought to light a rectangular structure, 113 feet long by 100 feet wide, three stories high, with an enclosed court on the south side. The ground plan showed the existence of four circular ceremonial rooms, compactly embedded in 50 rectangular enclosures which were formerly used for secular purposes. The remarkable feature of this ruin is the large size of one of the circular rooms, situated in the center of a compact group of chambers. From the wide southerly outlook this ruin has received the name, Far View House. It is a pueblo habitation; the first of its type ever brought to light on the plateau. The ruin was repaired, the tops of the kivas being treated with Portland cement to protect them from the elements.

After describing the various architectural details of the building Dr. Fewkes passed to a consideration of what he termed the morphology of the structure, or the comparison of it with other types, especially the cliff dwellings of the Mesa Verde. He declared that it is a new type of ruin for that region, and that there are evidences of many other examples of the same general character now indicated by mounds; we may say that formerly there were as many members of this type on the Park as cliff dwellings in the caves of the canyons.

*From a paper read by Dr. J. Walter Fewkes, of the Bureau of American Ethnology, before the Anthropological Society of Washington, and published in the Journal of the Washington Academy of Sciences.

He considered in detail some of the arguments bearing on the relative age of buildings like Far View House, and the cliff dwellings, and came to the conclusion that the former were the more recent, and evolved from the habitations in cliffs.

Considerable time was devoted to a discussion and comparison of the so-called kiva or sacred room. He held that this chamber should be made the basis of classification of pueblo ruins, and that it was represented by the tower found widely distributed in Utah and adjacent regions of Colorado. He pointed out the widespread custom of dual styles of buildings among primitive races, one type being devoted to religious purposes, the other to habitations. He claimed that the former are always better constructed than the latter. He regarded the tower as a religious building and thought that the people who used it lived in dugouts or temporary habitations that have disappeared. In the earliest times these two types were separated, but in later stages in the evolution of buildings they became united, and habitations were constructed around the bases of the towers. Later in the course of development the central original building lost its tower-like form and became the circular kiva. Several similar architectural units, by union, formed a pueblo.

Dr. Fewkes pointed out that the great morphological similarity between Far View House and the pueblos with central kivas and towers, many miles away, had an important bearing on the distribution or diffusion of pueblo culture. He regarded the San Juan region as the nucleus from which the pueblos south and west originated, thus substantiating by archæological evidence the legendary traditions of the inhabited and much modified historic pueblos. He claimed that there were two nuclei of distribution of house builders in the southwest, each arising in regions physiographically and climatically distinct, each possessed of different materials available for architectural advancement. One arose in the Gila Valley, the other in the San Juan; the former spread toward the north, the latter to the south. Both nuclei were extinct before the historic epoch. What remained, or that which we now know as the culture of living descendants, is the product of acculturation, due to cultural contacts in this expansion. History can afford, therefore, only an imperfect picture. We must rely on archeology, mainly architectural, and ceramic remains, supplemented by ethnology, to discover the nature of the culture of these two original nuclei.

In a discussion of their distribution the speaker showed numerous illustrations of the prehistoric kivas, called towers, situated in Hill Canyon, near Ouray, Utah. To these he gave the name, suggested by their site, Mushroom Rock ruins. Their more striking peculiarity is their position on the tops of inverted cones, or mushroom-like formations of rock, produced by the enormous erosion evident in the region where they occur. He said that this form of ruins was not morphologically a different type from towers, but their site was so unusual that it was convenient to designate them by this name.

While the important question of the antiquity of the cliff dwellings has not been satisfactorily answered by the observation made at Far View House, progress is being made in the accumulation of significant data bearing upon it. As long as this question remains unanswered the archeologist has plenty of research before him for many more years of field work in the Southwest.

Examination of Artificial Leather and Leather Substitutes

Fats and unsaponifiable fatty matter, incompletely sulfonated oils, and part of the caout-chouc, gutta-percha, oxidized oils and resins, pitch, tar, or asphalt present, are removed by extraction with ether and petroleum spirit, and glue, etc., gums, starch, tannin, glycerol, alkali soaps, and soluble inorganic matter removed from the residue by extraction with water. The residue from this treatment is treated with hydrochloric acid and shaken with ether to extract the fatty or resin acids of insoluble soaps, the bases and other inorganic matter being found in the aqueous layer. A further extraction with acetone removes cellulose esters, nitro- and acetyl-cellulose, as well as free sulphur and part of any vegetable fibrous matter present. Fully sulfonated oils, oxidized oils, decomposition products of leather and hide, and further portions of pitch, etc., are removed by alcoholic potash, and from the residue further portions of caout-chouc and gutta-percha and the remainder of the pitch, etc., are extracted by pyridine. A final extraction with toluene completely removes caout-chouc and gutta-percha, leaving a residue containing only plant fiber, etc., and insoluble inorganic matter. Details for the examination of the various extracts are given in the original paper.—Note in *Jour. Soc. Chem. Ind.* on an article by R. Lauffman, in *Z. angew. Chem.*

Cavitation*

A Study of the Screw Propeller

By C. H. Holst

The following notes are the result of a study of the data obtained from the progressive trials of a certain torpedo-boat destroyer, this being one of a number of similar studies, made with the special view of obtaining more detailed information about the questions relating to the action of ships' screws. In the accompanying diagram, Fig. 1, the black dots shown on the dotted horizontal lines indicate the data which were obtained from the trial results, and curves are drawn through these black dots to find the intermediate values, as is usually done in practice.

The curve AA indicates the velocity of the vessel expressed in meters per second. That marked BBB indicates the corresponding number of shaft horse-power delivered to each of the vessel's propellers, while the straight line C indicates the value of "pitch" per second, expressed in meters, this value being obtained by multiplying the "pitch" of the propeller by the number of revolutions per second, corresponding to either "velocity of ship" or "shaft horse-power" shown in the two first curves. Dividing the total number of shaft horse-power by each separate number of revolutions per second, a new curve DD is easily set out, representing graphically the number of shaft horse-power required per revolution per second of the propeller. This curve is thus in true accordance with the published trial results.

An examination of these curves leads to some conclusions which, according to my views, throw considerable light on certain questions concerning propeller action, and it is this examination and its consequences to which I desire to call attention.

To begin with the curve A. Up to fully 9 revolutions per second the curve is a nearly straight line, diverging from the straight line C, in a nearly constant proportion, and indicating that the ratio between "pitch per second" and ship's velocity per second remains nearly constant up to that limit—in other words, it indicates a nearly constant percentage of "slip." But at an increasing number of revolutions per second the curve A plainly indicates an abnormal augmentation of this "slip" percentage, until, between 13 and 14 revolutions per second, the curve, having changed nearly into the vertical direction, points to such a slow increase in velocity, when compared with the continuously increasing line of values for "pitch per second," that the conclusion is evident that, however the number of revolutions may increase, the velocity of the vessel will not increase at all, or very insignificantly only.

Examining curve BB in its lower part, we shall see that the values for shaft horse-power originally increase at a ratio of nearly the cube of the number of revolutions; for instance, 420 shaft horse-power at 6 revolutions and 3,400 shaft horse-power at 12 revolutions, 250 shaft horse-power at 5 revolutions and 2,000 shaft horse-power at 10 revolutions, an increase which corresponds fairly with the general assumptions. But instead of going on at the same ratio, in comparing 7 with 14 revolutions, we shall find, from the trial data, 630 shaft horse-power at 7, against only 4,600 shaft horse-power at the higher number of revolutions, and thus the curve of total horse-power, in showing the tendency to become a tangent to the broken straight line drawn from B to the zero point, indicates that the maximum power of engines per revolution is being reached.

There can be no doubt that this change in the direction of curve B, as well as of curve D, must take place. When, and as soon as, the maximum of steam pressure is reached in the cylinders of a reciprocating engine, or the maximum of impulse in a steam turbine, *the power per revolution* cannot be increased, any subsequent increase in power can only follow from an increased number of revolutions per second, and this increase is only proportionate to the "first power" of the changing number of revolutions instead of to the cube.

The propeller, however, as shown by curves A and C, is acting under quite different conditions. At every increase in number of revolutions its "pitch per second" increases in direct proportion, and that fraction of "pitch per second" which represents the velocity of the ship ceases to increase, or increases only very slowly.

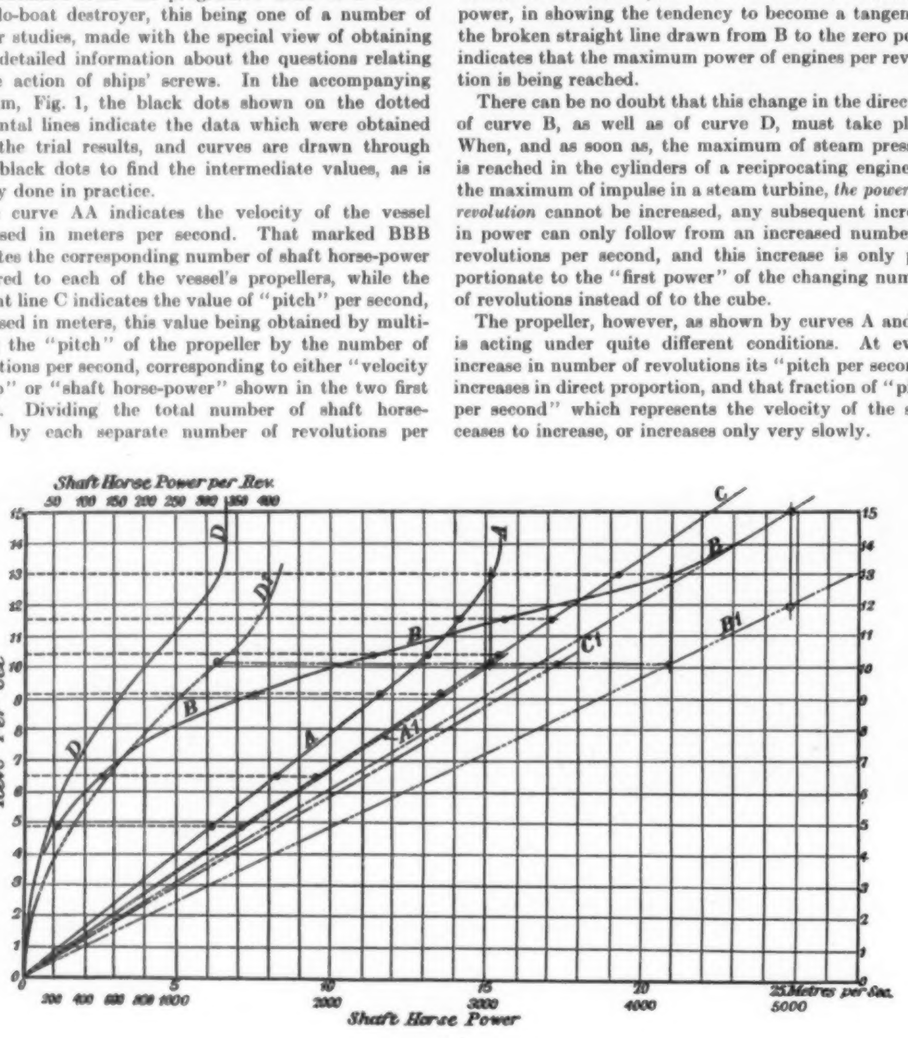


Fig. 1

But, then, that part of "pitch per second" which is termed "slip" increases enormously, and as "slip," according to the author's views, must be a measure of, or bear a certain proportion to, "the pressure exerted by the propeller to drive the ship ahead," this "pressure" must also increase enormously with the increasing slip.

Perhaps it will be necessary to explain this more fully before going further. The power of any engine is to be expressed in the product of so many tons of pressure of any kind, exerted over so many meters per second, resulting in so many meter-tons, equivalent to so many horse-power, 1 horse-power being equal to 0.075 meter-ton or to 75 meter-kilogrammes per second.

The same units must be used when dealing with power-absorbing instruments, such as ship's propellers for instance, and thus the work required to drive a propeller, and by means of that propeller to drive a ship, may be and must be expressed in so many tons of pressure exerted over so many metres, this latter value being the distance covered by the ship in one second.

Other studies on this same subject have enabled the author to determine accurately the amount of this pressure under various conditions, but it is evident that this pressure in question can never have a greater value than that found by dividing the number of meter tons corresponding to engine power by the number of meters of ship's velocity per second. It has been stated that on "nearing cavitation" a screw propeller attains a maximum of effect—and from this statement we may conclude that in this present example the maximum to be expected may be approximated as follows:

Maximum shaft horse-power per revolution to be obtained from engines....	330 s.h.p.
Equal to 330 by 0.075..................	25 m.-tons
At 14 revolutions per second, 25 by 14..	350 "
Maximum speed of ship per second....	15.40 m.
Thus maximum pressure to be expected 350 ÷ 15.4 m. per second............	22.70 tons

but also:

25 m. tons at 15 revolutions per second will give..........................	375 m.-tons
Maximum speed of ship remaining....	15.40 m.
Thus maximum pressure to be expected 375 ÷ 15.4 m. per second............	24.30 tons
And at 16 revolutions per second, according to same reasoning........	400 m.-tons
And maximum pressure to be expected, 400 ÷ 15.4.........................	26 tons

From the above we may conclude that the engine power, as increasing with the number of revolutions, is being absorbed by causing a "slip" producing "pressures per unit" of an increasing magnitude, and, further, that "if such increasing pressures per unit do not produce a greater speed of the ship, the number of units on which this pressure acts must decrease proportionately," so that a nearly constant value of "total pressure" is obtained, always equal in certain proportion to the resistance of the ship.

This condition can only be fulfilled when the active blade surface of the propeller is gradually diminishing—as it will be—by a gradually diminishing annular surface of the propeller, caused by want of engine power to drive the water, at the corresponding speed, through the original annular space. This original annular space is the "disc area" of propeller minus area of boss. The author's assumption is that the action of the propeller, when nearing the limit of "cavitation," is such as to automatically increase the diameter of this inner ring until, the diameter of outer and inner ring becoming equal, there remains no blade surface to act upon, however high the pressure per unit of surface has been just before, when that pressure, acting only on the outer tips of the blades, was as yet equal to what would have been a normal pressure on the full original surface of the blades.

Some evidences in favor of the views explained above may here follow. Supposing the same vessel had been fitted with engines capable of developing the same value of shaft horse-power at 12 revolutions per second as the original engines at 15 revolutions per second, then the line B1 zero would show the maximum of power to be obtained at any number of revolutions.

The same ship, requiring the same power to go the same speed, would then go 15.2 meters per second at 10.15 revolutions of engines, as shown graphically by A1, and the curve D1 shows the increased values of shaft horse-power per revolution of the heavier type of engine.

Naturally, this engine would require a propeller of different pitch, were it only to secure a "pitch per second" which, apart from any fixed or arbitrary percentage of "slip," must at least be something in excess of the vessel's speed. The straight line C1 gives the "pitch" per second for a propeller with a "slip" equal to that of the former screw in its lower numbers of revolutions, the horizontal distances between A and C being the same as between A1 and C1.

A propeller of that "pitch per second" will continue to work, under the assumed conditions of engine power and speed, at 10.15 revolutions per second, "without any reduction of its original blade area," whereas calculations, based on the principles explained above, have shown that the particular propeller here described only worked at the diminishing areas shown in Table I, subjoined, 1.35 sq. m. being the original value:

Table I

At 6 revolutions, 1.35 sq. m.: Pressure per unit 2.97 tons...............	4.02 tons
4.02 tons by 7.60 m. speed.......	30.5 m.-tons
30.5 m.-tons being equal to.......	408 s.h.p.
Or 68 s.h.p. per revolution	
At 8 revolutions, 1.35 sq. m.: Pressure per unit 5.240 tons..............	7.33 tons
7.33 tons by 10.10 m. per second..	74 m.-tons
74 m.-tons being equal to........	990 s.h.p.
Or 124 s.h.p. per revolution	
At 10 revolutions, 1.35 sq. m.: Pressure per unit 8.880 tons..........	12 tons
12 tons by 12.60 m. per second....	151 m.-tons
151 m.-tons being equal to.......	2,010 s.h.p.
Or 201 s.h.p. per revolution	
At 11 revolutions, 1.24 sq. m.: Pressure per unit 12.100 tons by 1.24 .	15 tons
15 tons by 13.65 m. per second...	205 m.-tons
205 m.-tons being equal to.......	2,680 s.h.p.
Or 244 s.h.p. per revolution	
At 12 revolutions, 1.04 sq. m.: Pressure per unit 17.100 tons by 1.04 .	17.800 tons
17.8 tons by 14.52 m. per second..	257 m.-tons
257 m.-tons being equal to.......	3,432 s.h.p.
Or 286 s.h.p. per revolution	
At 13 revolutions, 0.70 sq. m.: Pressure per unit 29.700 tons by 0.70..	20.7 tons
20.7 tons by 15.2 m per second...	315.5 m.-tons
315.5 m.-tons being equal to......	4,200 s.h.p
Or 322 s.h.p. per revolution	

*From *Engineering*.

At 14 revolutions, 0.465 sq. m.: Pressure per unit 48.5 tons by 0.465...	22.4 tons
22.4 tons by 15.4 m. per second.....	345 m.-tons
345 m.-tons being equal to.......	4,600 s h.p.
Or 328 s.h.p. per revolution	
At 15 revolutions, 0.298 sq. m.: Pressure per unit 81.5 tons by 0.298...	24.2 tons
24.2 tons by 15.4 m. per second...	372 m.-tons
372 m.-tons being equal to.......	4,960 s.h.p.
Or 330 s.h.p. per revolution	

Thus, we find that the original blade surface of 1.35 sq. m. has been gradually reduced to 0.298 sq. m. when running at 15 revolutions per second, which means, for the screw propeller chosen here as an example, that with the outer diameter of 1.60 meters the inner diameter of the annular space has increased from that of the boss or 0.40 meter to 1.38 meters, thus leaving as active part of the blades only a width of 0.11 meter from the outer tips.

This changing of conditions must explain, according to the author's views, the cause of "cavitation," as at a still greater number of revolutions these last 11 centimeters will also become inactive and "cavitation" must take place.

What then happens about the propeller will be, as the author is led to believe, not the entering of air into the sphere of propeller action, but the flow of a stream of water through the propeller at such a velocity that, "being equal to the velocity of the propeller," no pressure can be obtained by the difference, which has produced the effect up to this critical point. Very likely the next moment to that in which "cavitation" begins the water surrounding the propeller will be "churned," as it were, by the propeller blades, and this "churning" will necessarily cause a mixture of water and air, as is to be observed in all cases where propellers are being driven at speeds not corresponding with the ship's velocity, *i. e.*, when a ship is trying her engines while moored to a quay, or when the engines are going astern while the ship is still making headway.

This gradual widening of the boss of a propeller into an annular surface inside the screw disc is met with in a great many cases of propellers which the author has been able to examine, and the example given in the preceding lines does not stand alone in its kind. It was chosen simply because, by dealing with a full set of data of a "progressive trial" for this given propeller, the process described may be followed, as it were, step by step.

Other propellers give similar indications of working with a reduced blade area quite independent from the values of their respective diameters, or surfaces, or pitches, or from the total amount of horse-power transmitted, but they all invariably show the same symptoms from the moment the number of horse-power per revolution becomes insufficient to throw the water backwards through the full area of propeller disc area less boss area.

It may be interesting to give some more particulars about the propellers above referred to. The one which was discussed first had the following leading dimensions:

Diameter, 1.60 m.; pitch, 1.48 m.	Three blades.
Developed area in total...........	1.35 sq. m.
Shaft horse-power transmitted at 13 revolutions per second..........	4.200 h.p.

Another example was furnished by the following:

Diameter, 2.35 m.; pitch, 2.08 m.	Three blades.
Developed area in total...........	3.05 sq. m.
Shaft horse-power transmitted at 9.35 revolutions per second......	9.320 h.p.
Shaft horse-power per revolution per second..................	1,000 h.p.

The velocity of the ship in this case was equal to 15.20 m. per second, as in the first case considered. The maximum pressure to be given by this screw is thus found as follows:

9.321 shaft horse-power is equal to.	700 m.-tons
700 m.-tons divided by ship's velocity = 700 ÷ 15.2, gives pressure..........................	46 tons
Pitch per second 2.08 by 9.35 revolutions per second................	19.45 m.
The ship's velocity was equal to....	15.20 m.
Leaving for value of "slip".......	4.25 m. per sec.
Producing a pressure per square metre.........................	33 tons
And requiring a blade area of......	1.385 sq. m.
To produce a total pressure of.....	46 tons

The original area thus being reduced from 3.05 to 1.385 sq. m., being 48½ per cent of the original and corresponding to an annular surface of 2.35 m. outside and 1.276 m. inside diameter.

Another example is furnished by the propellers of the Spanish destroyer Bustamente, described in *Engineering*, February 11th and 18th, 1916. In this case the particulars of the propellers are as follows:

Diameter, 1.28 m.; pitch, 1.14 m. Three blades.

The developed area is not given in the article referred to, but may be evaluated at about 0.60 sq. m.

Shaft horse-power transmitted at 17.65 revolutions per second.....	3,006 s.h.p.
Shaft horse-power per revolution per second........................	170 h.p.
The velocity of the vessel being in this case.....................	15 m. per sec.

The maximum pressure may be computed as follows:

3,006 shaft horse-power is equal to.	225 m.-tons
And 225 m.-tons divided by 15 m...	15 tons
Pitch per second, 1 14 m. × 17.65 revolutions....................	20.12 m.
Leaving for value of "slip" 20.12 —15.........................	5.12 m.
Producing a pressure per square metre of.....................	48 tons
And requiring a blade area of only..	0.313 sq. m.
To produce the available maximum of..........................	15 tons

If the original evaluation of 0.60 sq. m. has been correct this original area is reduced by nearly fifty per cent, the disc area being in this case reduced to an annular area having an outer diameter of 1.22 m. and an inner diameter of 0.85 m.

Perhaps still more remarkable evidence is found by analyzing the communication of Captain Dyson, of the United States Navy, which was published in *Shipbuilding and Shipping Record* of March 9th, 1916, where two three-bladed propellers are described, having very slight differences in dimensions, and producing widely different numbers of revolutions when transmitting the same power, and driving two exactly similar ships at the same speed.

The propellers are illustrated in Fig. 2 subjoined and the chief data are given in Table II. From these data we find the results given in Table III, corresponding in both cases with the reduction of active blade area.

TABLE II

	Propeller No. 1	Propeller No. 2
Diameter................	2.32 m.	2.35 m.
Pitch....................	1.98 m.	2.03 m.
Number of blades........	3	3
Developed surface........	2.58 sq. m.	2.62 sq. m.
Revs. per minute.........	611 or 10.183 per sec.	564 or 9.4 per sec.
Shaft h.p. transmitted....	8,000	8,000
Shaft h.p. per revolution per second............	785	850
Velocity of ship..........	15 m. per sec.	15 m. per sec.

TABLE III

	Propeller No. 1	Propeller No. 2
8,000 shaft horse-power is equal to..............	600 m.-tons	600 m.-tons
Velocity of ship..........	15 m. per sec.	15 m. per sec.
Pitch per second.........	20.19 m.	19.08 m.
Maximum pressure......	40 tons	40 tons
Leaving "slip" per second.	5.19 m.	4.08 m.
Producing a pressure per sq. m. of..............	49.5 tons	30.6 tons
And requiring a blade area of..................	0.81 sq. m.	1.315 sq. m.
To produce the total of...	40 tons	40 tons
The reduction of blade surface thus amounts to (of the original)........	31.25 per cent	50 per cent
The diameter of outer circle of annular space remains...............	23.2 m.	2.35 m.
The inner diameter being..	18.3 m.	1.36 m.

PROPELLER No 1		PROPELLER No 2	
Outer Dia.	2.32M	Outer Dia.	2.35M
Inner "	1.83 "	Inner "	1.36 "
Original Surface	2.58M²	Original Surface	2.62M²
Reduced "	0.81 "	Reduced "	1.315 "

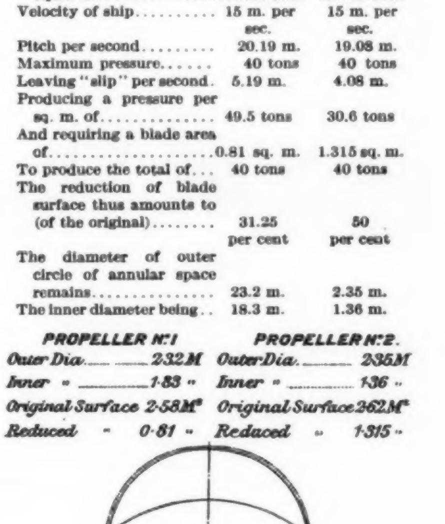


FIG. 2

With regard to propeller No. 1 it must be remarked that this propeller is working just at the limit of cavitation, as there is no perceptible difference to be found at an increasing or diminishing number of revolutions of engines.

At 11 revolutions per second the same total pressure of 40 tons is obtained with a "slip" per second of 6.75 m., producing a pressure per sq. m. of 84 tons and requiring a blade area of 0.48 sq. m. only, whereas the same pressure is obtained at 10 revolutions per second with a "slip" of 3.80 m., producing a pressure per sq. m. of 42.4 tons, and thus requiring a blade area of 0.95 sq. m. to produce 40 tons total pressure. Within this range the velocity of the vessel and the power of the engines remain absolutely the same, so that it is to be considered as being merely accidental whether the higher or the lower number of revolutions will be made.

The examples given above of propellers working with a reduced area of screw-disc, and with a correspondingly reduced area of blades, may be completed with one more example, showing that this same symptom is met with even at low speeds and with very small engine power.

From the description of Professor Peabody's "Experiments on the Froude," a paper read before the meeting of the Society of Naval Architects and Mechanical Engineers, held at New York, November 16th and 17th, 1911, we may take a striking example, by considering the conditions under which the propeller, described as No. 1, was working when driving the model of the United States cruiser "Manning" at a speed of 7 knots an hour, and thereby transmitting the insignificant power of only 8.25 shaft horse-power. This propeller had the following dimensions: Diameter, 24 in., or 0.61 m.; pitch, 26.4 in., or 0.67 m.; and a projected blade surface of 61 per cent of the disc area, equal to 0.176 sq. m.

Following the same reasoning as before we find:

Number of kilogramme-metres per second............................	620 kg.-m.
Velocity of ship per second...........	3.6 m.
Maximum pressure to be expected.....	172 kg.
Pitch per second at 395 r.p.m.........	4.40 m.
Leaving a slip per second equal to.....	0.80 m.
This slip producing a pressure per square m. equal to................	2.080 kg.
And requiring a blade surface of only..	0.083 sq. m.
To produce the total pressure of......	172 kg.

The developed blade surface was thus reduced to 48 per cent of the original projected surface, and this surface is found by calculation to lie between:

The outer diameter of the propeller....	0.61 m.
And an inner diameter of............	0.36 m.
Corresponding with the blade surface of..............................	0.083 sq. m.

according to the drawing of the propeller annexed to the description of these experiments.

It will perhaps be necessary to point out that the values found for what is here called "the possible maximum pressure," and obtained simply by dividing the number of kilogramme-metres per second transmitted to the shaft by the ship's velocity in metres per second, is not equal, and cannot be equal, to the actual "thrust" produced by the propeller. The actual thrust, *i. e.*, the pressure produced in the direction of the advance of the ship, and thus in the direction of the propeller shaft, has a value which, being always smaller than this "possible maximum pressure," depends on the combined influences of diameter, number of revolutions and slip in any separate case.

For the present it has only been the author's object to produce some examples of results obtained with his method of investigation, by means of calculation, and to demonstrate by the foregoing that this method gives such results as correspond with established facts met with in practice.

Practice has proved, for instance, that it requires 8,000 shaft horse-power to turn the propellers referred to in Captain Dyson's article respectively at 611 and 564 r.p.m., when these propellers are fitted to similar boats, having a velocity of 15 m. per second, corresponding with that power, and practice has also proved that it requires 8.25 shaft horse-power to turn the propeller of Professor Peabody's model boat at 395 r.p.m., when fitted to the model having a velocity of 3.60 m. per second, corresponding with that power.

Practice, again, has proved that the propeller dealt with in the first part of this study required "so many" shaft horse-power to turn at "so many" revolutions, when fitted to a boat attaining subsequent velocities of "so many" metres per second, and calculations "based" on other figures, or giving other figures as "results," would be worthless.

The calculations should correspond with the facts with an "accuracy" of 100 per cent, as only if this result of accuracy is obtained can such calculations be accepted as being trustworthy, and suitable for being used as a base for further investigations. It is this accuracy which is claimed by the author of this study, and it is his object to point out in subsequent articles that this same method has been invariably adhered to when trying to explain whatever facts are stated in and by actual practice.

The foregoing article deals only with the question, "How much power is required to turn a given screw-propeller under various conditons?" Another and quite separate question is to be answered when studying "How much power is required to drive a given ship by means of that propeller?" In other words, there is a difference, and sometimes a very considerable difference, between shaft horse-power and effective horse-power to be taken into account. This fact is without any doubt also one of the facts proved by practice.

Silent Warfare*

Devices for Reducing Noise and Flash of Guns

By Nicholas Flamel

To see unseen, to hear unheard, these are the two greatest factors in success in tactics and in strategy. In short, it is of as much importance to know the weak points and the strength of the enemy as to hide one's own.

Our batteries, however, no longer belch forth clouds of smoke to reveal their position and injure their aim and we owe this to M. Vieille, who was the first to achieve a really stable powder, yet unquestionably durable.

Smoke nowadays plays a part in war only to form a momentary mask, to enable aviators to indicate the emplacement of batteries or the arrival of reserves, or to regulate the aim by means of the explosion. This limits its rôle, which is a very important one.

Chemical Processes.—Though it has been possible to suppress smoke by the use of powders that contain no mineral substances, of pure nitrocellulose and of nitrocellulose and nitroglycerin, it has not been possible to suppress flame or flash. The Germans were the first to try to diminish flashes by adding to powders very small quantities of the salts of fixed alkalies or of the alkaline-earth metals such as the salts of calcium. They did not succeed. With cannon the flash always exists, though it is diminished, to be sure; but the moment the flame becomes less visible, smoke appears.

In the case of howitzers and mortars and in general in the firing of all short guns, of low caliber length, the flash has low visibility, even without the aid of mineral substances.

The most varied substances have been proposed to be added to smokeless powders to deaden the flash—vaseline, alkaline bicarbonates, alkaline and alkaline-earth soaps, oxalates, resinates of soda, of baryta and of alumina.

M. Villa[1] placed paraffine and hydrate of magnesia above the powder in small bags using it in the form of grains for small guns and in the form of discs, lozenges, or sticks, when placed in the cartridges of cannon.

The proportion varies according to circumstances from three per cent to ten per cent of the weight of the charge. The hydrated magnesia constitutes 78 per cent of the mixture. In reality, no efficacious solution of the problem has been discovered.

Among all these ingredients the salts of the fixed alkalies alone seem to be able to act in a preponderating manner, according to the experiments of Dantriche[2] upon the amount of heat disengaged during the explosion of explosives. (See table below.)

GUN COTTON

10% Nitrogen	
Alone	184 calories
With 1% $CO^{3}HNa$	88 calories
With 2% $NO^{3}K$	88 calories
With 2% $CO^{3}Ca$	152 calories
With 4% $CO^{3}Mg$	152 calories
9% Nitrogen	
Alone	164 calories
With 10% $CO^{3}HNa$	61 calories
Trinitrotoluene	
Alone	250 calories
With 2%	117 calories
With 5%	66 calories
With 10%	66 calories
With 10% $N^{2}O^{6}Ba$	175 calories

The alkaline earth metals, calcium, barium and magnesium have a much slighter action. It is possible that the presence of alkaline salts in the powders plays a similar rôle.

In 1888 the Commission on Explosive Substances found that the products of detonation of 10 per cent nitrogen gun-cotton did not take fire in the air; but at this period the gun-cotton contained two to four per cent of sodium carbonate. For the last ten years the German powders of Rottweil have had added to them from one to three per cent of alkaline fixed salts. This solution presents serious inconveniences in the case of some powders.

The diminution in the quality of heat so advantageous for the so-called safety explosives utilized in the working of mines containing explosive gases notably modifies the energy of the powder. The presence of fixed mineral salts augments the deterioration of firearms and the production of smoke. In the same measure that the flash diminishes in intensity the quantity of smoke is augmented. We can almost lay down the following law: The total sum of flame plus smoke remains constant.

Nevertheless there has been some progress achieved and the attenuation of the flame, with a very light smoke, is a sufficiently satisfactory solution in the majority of cases. At nightfall smoke ceases to be visible, while the slightest flash reveals a gun. Smoke matters so little at night that black powders have often been used.

The problem of the suppression of flashes has been otherwise solved. Cannon are essentially nothing but explosion motors, of medium yield and very short duration, a few minutes at most; without speaking of the mechanical results there remains after the departure of the projectile, in the chamber of the gun, a mixture of combustible gases, under pressure and at a high temperature, in which carbon monoxide predominates. Such a mixture does not take fire nor continue to burn except in the presence of oxygen; also it would be possible either to dilute the proportion of carbon monoxide or to cool the gases suddenly by forcing them to effect a new decomposition action after having communicated to the projectile a sufficient initial speed. If we reflect that this dilution or this cooling must be produced in less than one one-hundredth of a second in order to prevent the mixture of gases escaping from the mouth of the piece from taking fire, we can but wonder what could produce this new reaction, also of explosive nature, so quietly. But might it be, perhaps accomplished by employing large sparklets filled with liquid carbon dioxide, reservoirs full of water or receptacles filled with compressed nitrogen, which would burst at the moment of firing?

Mechanical Processes.—If this solution were adopted and the flash accordingly vanished the presence of the piece of artillery would still be betrayed by the noise. But it should be unheard as well as unseen. By mechanical processes it is possible to arrive at a more general solution of diminution of flash and deadening of noise. At the present time we cannot dream of obtaining a cannon both flashless and silent. And yet this is what M. Humbert pretended to have discovered nearly fifteen years ago. In reality he had studied out only a device for a rifle. This apparatus was described at the time, with illustrations, in *France Militaire*. Its object was to suppress smoke, flame, and sound in fire-arms.

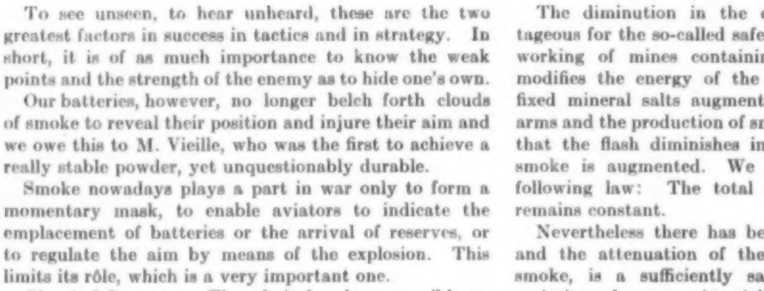
It consists of a steel tube having compartments separated by partitions pierced by orifices of a diameter slightly greater than the caliber of the arm. This tube is affixed to the rifle by a screw thread, either continuous or interrupted, or else in the same manner as the bayonet. It is not attached to the rifle until the moment of firing. On the march it is used as a cane or fastened to the knapsack like a tent picket. It operates thus:

When the bottom of the projectile is engaged in the tube, a portion of the gases which follow it expands in the shape of the frustrum of a cone on passing the muzzle of the gun, and is arrested by the first partition of the tube. Thereafter in the same manner, as the projectile increases its distance from the muzzle of the arm, it is followed by a quantity of gas which becomes smaller and smaller, until it reaches the point of issue, where the quantity is so minimal that it is insufficient to produce either noise, flame or smoke.

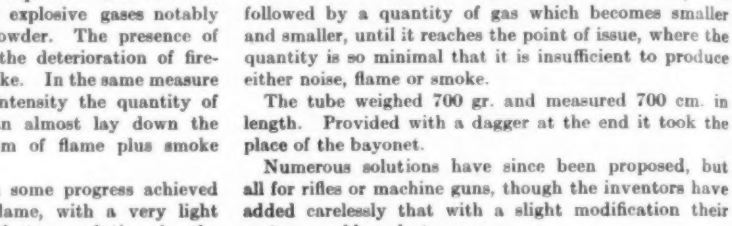
The tube weighed 700 gr. and measured 700 cm. in length. Provided with a dagger at the end it took the place of the bayonet.

Numerous solutions have since been proposed, but all for rifles or machine guns, though the inventors have added carelessly that with a slight modification their system would apply to cannon.

A Russian, M. Evangelidi,[3] conceived the idea of forming a vacuum in the rifle in front of the ball and in a reservoir. To this end, a tube A (Fig. 1), is provided at one extremity with an orifice of the same diameter as the rifle, with a lock permitting it to be fastened upon the arm. The other end the tube A is closed by a box B in the form of a duck bill. This bill is kept closed by springs C (Fig. 2). In the walls of a tube A are openings D located with reference to larger openings arranged in the vacuum reservoir E. A partial vacuum is produced in this reservoir by the aid of the piston F pulled by the wire G (Fig. 1). This is hooked to the stock of the gun before the shot. Fig. 1 represents the complete mounting.



Figs. 1 and 2.



Figs. 4 and 5.

This device, despite its ingenuity, is hardly compatible with the rapid fire demanded in the present war. Neither can we see how it can well be mounted on a cannon.

With M. Hiram Maxim it seemed that the solution must be nearer and more certain, and numerous patents were taken out by him. The sound was suppressed by avoiding the violent impact of the compressed gases against the surrounding air on issuing from the barrel. This was a *silencer*. We will try to trace the many modifications it has undergone.

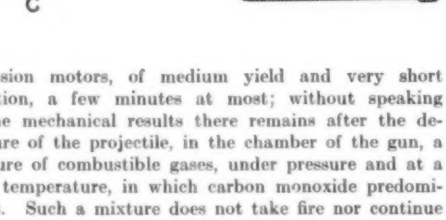


Fig. 3.

This device, whose weight varies from 170 to 250 gr. is formed of a sheet steel 38 mm. in diameter and 100 to 150 mm. long, according to the variation of caliber of from 6 to 7.5 mm. It is placed at the muzzle of the gun by means of an attachment similar to that of the bayonet. Figs. 3, 4, 5 represent the apparatus at the end of the gun, dismounted and show the interior arrangement of the compartments formed of 10 to 13 discs of sheet iron. Maxim expects to extinguish the sound more rapidly by communicating a whirling motion. At first he arranged the diaphragms symmetrically with respect to the axis of the bore (Figs. 6, 7 and 8). In the case are vanes like those of a turbine; they do not quite touch the walls of the case, so as to permit the gases to whirl. Thus they follow the path of a screw. To augment the speed of rotation the inventor disposed his silencer dissymmetrically to the axis of the bore (Fig. 5); he thus forced the gases to revolve also around the longitudinal axis of detonation and of the envelop. He compares the phenomenon to that of which water comes with great speed into the bottom of a reservoir.

If the rotary movement of the liquid is great it runs off through the overflow slowly.

The reasoning seems ingenious; the gases moving longitudinally with a high speed due to the heat and pressure are obliged to whirl, and like the water, cannot escape except slowly. But Mr. Maxim did not find this solution practical. He therefore conceived another entirely different in principle.

He hoods the end of the rifle with an annular chamber which may have two different forms (Figs. 9 and 10).

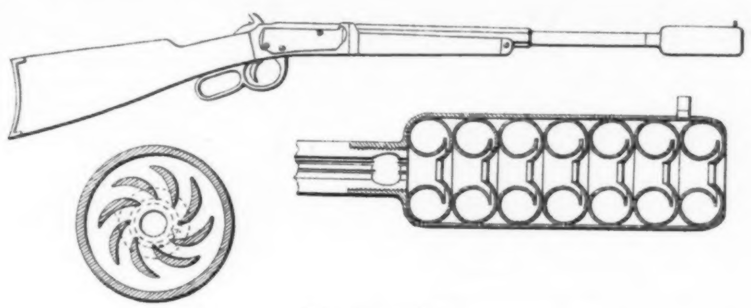
This muffling chamber A is divided by one or two transverse partitions into two or more compartments of relatively large volume. The first B surrounds ports cut in the gun itself. The making of automatic guns had quite naturally led to this conclusion; the taking of the gas from the side diminished the recoil and deadened the sound a little. In Fig. 10 the second chamber is

*Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from *La Nature*.

[1] Br. Français, No. 385, 769.

[2] C. R. t. 146, p. 535, 1908.

[3] Br. Français No. 356, 256, July 20, 1905, July 27, 1905, Nov. 24, 1905.



Figs. 6, 7 and 8.

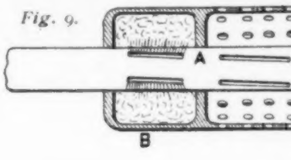


Fig. 9.

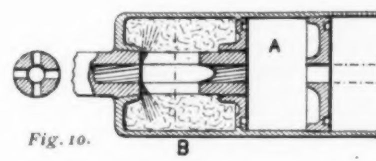


Fig. 10.

prolonged by a tube which permits the bullet to cover the larger opening by which it escapes for a longer time. and also permits the gases to diffuse gradually. From every point of view this device is superior to the preceding ones. Tested in England in 1910 results showed its possible usefulness.

The Spanish Commission examined at the same time the "*silencieux*" offered by a Frenchman, M. Bordenave. This silencer, light and simple, suppressed the sound so well that at the distance of 10 meters nothing could be heard. It consisted of three parts; one part shaped like the frustrum of a cone and fastened to the gun; another, of a narrower diameter, through which the bullet escaped. These two parts were united by a larger cylinder filled with helicoidal diaphragms. The wall of this cylinder was pierced by escape holes.

In Germany the problem is actively studied. The silencer for portable fire-arms of all kinds and for machine guns, patented by M. Gustave Genschow and the Aktien Gesellschaft (Br. Français, No. 409-595, April 26, 1910,) forces the gases to traverse a rather lengthy path at their issue from the gun-bore by placing three or four cones A with the narrowest aperture turned toward the gun (Fig. 11). These cones bear upon their external surface helicoidal channels with corrugated walls corresponding to the walls of the tube-envelop *B*. The cones are separated by circular diaphragms formed by rings from which the gasses successively expand.

In the envelop *B* openings are made at regular intervals permitting the gases to be diffused in the atmosphere. The inventors contemplated the use not only of metals, such as iron, copper, or aluminum, but also of glass and porcelain, which is peculiar, to say the least! Like the cylindrical silencer filled with vanes and diaphragms by Maxim, the device invented by George Furgison Childress (Figs. 12 and 13), contains a series of split spheres. He hoped to obtain a whirling motion of the gases. These spheres are of aluminum and their number varies with the caliber.

The apparatus of M. Thurber (Fig. 14), recalls that of Maxim in the number and arrangement of the diaphragms and as in the German silencer described above. The diaphragms take the form of frustums of cones, whose smaller section is turned toward the barrel of the rifle. The only novel idea is the use of a perforated tube to envelop these tubular frustrum-shaped pieces. A still larger perforated tube *B* again surrounds the preceding tube *A*. To prevent the two rapid expansion of the compressed gases steel wool is interposed between the two tubes.

King (Fig. 16), makes the bayonet serve as silencer. It expands near the base to form a magazine containing diaphragms, yet is still able to act as bayonet as we see in Fig. 17, which shows an end view.

The new and interesting idea patented by this inventor, (Br. fr. No. 423,170, November 30, 1910; February 9th, 1911; April 10th, 1911) is to make a muffler which avoids the use of a supplementary piece which complicates the arms and equipment of the soldier. Because of their helicoidal form, the diaphragms enclosed in the bayonet again compel the gases to take a whirling motion. This movement absorbs a great deal of their kinetic force.

Moore (Br. fr. No. 443,271, March 27th, 1912, July 10th, 1912, September 20th, 1912), has gone still further on the road to muffling the sound and smothering the flame; he claims to entirely prevent the issue of the gases. Hence he is quite sure, if he succeeds in accomplishing this, of completely suppressing all sound and all flash. He utilizes in his apparatus (Fig. 18), a special arrangement of diaphragms. These serve, as we already know, to retard the speed of the gases, but besides this, a certain number of these diaphragms are disposed in such a manner that they drive back a certain quantity of gas. These oppose an obstacle to other gaseous streams and the gases are no longer able to escape. To avoid deterioration of the muzzle of the gun from the action of the hot gases driven back, successive enlargements *A* open up before the gas current and a compartment *B* in the form of a snail-shell drives it back to the lower part of the arm and a little behind the muzzle.

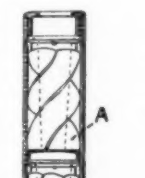
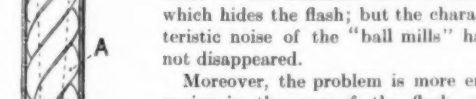


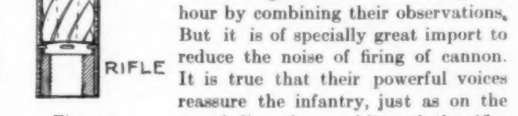
Fig. 11.

Such devices are not yet in use, at least under the form described above, but for a long time American hunting guns have been furnished with mufflers. Lefaucheux guns were made in France more than twenty-five years ago after the ideas of Captain De Place. Our mitrailleuses as well as those of the Germans have a mask which hides the flash; but the characteristic noise of the "ball mills" has not disappeared.

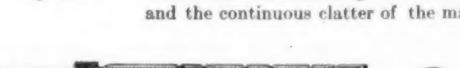
Moreover, the problem is more engaging in the case of the flash, especially when it is an affair of cannon which are long and of great range. At twilight or night, two observers with stop-watches having luminous dials can locate a battery by noting the time; or three observers can do the same thing even without noting the hour by combining their observations. But it is of specially great import to reduce the noise of firing of cannon. It is true that their powerful voices reassure the infantry, just as on the trench line the crackling of the rifles and the continuous clatter of the machine guns keep up the courage and brace the nerves; but it is also true that by its intense repetition this big noise of the cannon has almost as great a depressive effect as the bursting of shells.



Figs. 12 and 13.



Figs. 14 and 15.



Figs. 16 and 17.

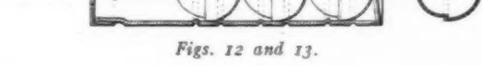


Fig. 18.

The ideal thing, apparently, would be to have on our side a row of invisible and silent cannon and on the other side the enemy upset by explosions and noise.

Our enemies have already created stations for locating batteries and directing fire by means of sound. These are known as Sound Observation Posts and utilize the sound of the shot, when the wind is not too strong, less than 5 meters per second, to locate the emplacement of our big guns and batteries.

Perhaps our pieces will reveal themselves by other sounds, or other methods, among them by the seismograph, which has been studied with this purpose since 1907 by an Austrian professor, M. Belar, who pretends to discern the number of hostile batteries and even, by the reverberation, their location. It is probable that these seismographs are a good deal falsified by the bursting of our projectiles and the fire of the enemy's guns. But certain results have been obtained.

Melting Copper Nickel Alloy by Gas

The melting of the metals which go to make the cupronickel alloy required for the envelopes of .303 bullets is a process which requires very careful handling. The alloy consists of copper and nickel, and the copper, as is well known, readily oxidizes, while nickel is a metal much given to absorbing impurities from the products of combustion unless special care is taken during the melting. Some casters will first melt scrap cupro-nickel, then the copper, and finally add the nickel, which dissolves in the molten metal, thus forming the alloy; on the other hand, the copper and nickel are sometimes put in together. The nickel is not melted, but dissolves in the molten copper at a lower temperature than would be required for melting pure nickel. Cupro manganese is added at the end of the melt as a deoxidizer, some means being provided for immersing this alloy below the surface of the metal in the crucible.

The greatest care must be taken in the whole of these operations, as the melt is very easily spoiled. For this reason gas-furnaces are particularly suitable for melting this alloy, as the heat can be rapidly attained, and the metal is not in the furnace longer than necessary, so that it has very little opportunity for absorbing impurities. As soon as the metal commences to melt a cover is placed over the pot to keep out the products of combustion and to protect the contents of the crucible as far as possible. Gas-furnaces are capable of exactly repeating these melting operations, and, unlike coke-furnaces, they can be timed to give melts at regular periods, because the fuel is under complete control by means of indictor-taps, which enable the proportions and quantities of gas and air supplied to the burners to be repeated time after time with absolute exactitude.

By means of a patent furnace-burner recently brought out the heat required for melting cupro-nickel can now be attained by gas at ordinary town pressure with an air-blast of about 3-pound pressure, and standard furnaces are made to take crucibles of a capacity up to 250 pounds of brass. Larger furnaces of the same type are made for melting brass, copper, and other metals and alloys, with crucibles up to 300 pounds of brass, which is, generally speaking, the maximum for furnaces where crucibles have to be lifted out for pouring.

For melting cartridge-metal and pouring it into strips for rolling, the latest development is a gas heated tilting crucible furnace, in which the trunnions upon which the furnace body turns are in line with the lip of the crucible, which is of 600 pounds-capacity, so that as the furnace-body is tilted the pouring-point is practically constant. By means of a turntable, or by a trolley running on rails in front of the furnace, moulds sufficient to take the whole contents of the crucible can be brought successively under the pouring-point, and the crucible emptied with maximum rapidity. The furnace is tilted by means of chains attached to the front of the base of the furnace body and passing over sprocket wheels controlled by hand-gear to a counter-balance weight in the rear. When the furnace-body is down on the base-plate and the crucible charged before melting, a pre-heater is swung over it and lowered upon the top of the casing; a sleeve in this pre-heater corresponds with the opening of the crucible and serves to extend it so that more ingots can be added to complete the charge. When it is required to pour the metal, the pre-heater is lifted clear of the furnace-body and swung out of the way.—*London Daily Telegram.*

Combustion of Gasoline

The range of complete combustion of mixtures of gasoline vapor and air is very narrow, according to an investigation made by the Bureau of Mines, which showed that it was limited to mixtures containing only between 1.5 and 2.5 per cent. The amount of carbon dioxide produced reaches a maximum at 2.5 per cent of gasoline vapor. At this point, as the percentage of gasoline vapor increases, carbon monoxide begins to form. At 4.1 per cent of gasoline vapor there is produced 14.0 per cent of carbon monoxide.

Precision in Chemical Weighing—II*

Notes on the Apparatus To Be Employed and Methods of Using It

By William Norman Rae and Joseph Reilly

Concluded from Scientific American Supplement No. 2157, Page 288, May 5, 1917

When obtaining the weight of a substance very accurately the following procedure should be followed:—The pointer is observed through a reading telescope two or three meters away from the front of the case. This enables the observer to estimate to a tenth of a scale division with fair accuracy, avoids errors due to parallax, and prevents the parts of the balance being unequally heated by radiation from the observer's person. If artificial illumination is used it should be from directly behind and above the observer. The balance case is often covered with a non-conducting jacket, leaving only a small aperture for the observance of the scale. The pans are dusted with a camel-hair brush kept for that purpose, the case is closed and the beam released and left to swing for twenty minutes to become thoroughly fatigued. This avoids small errors due to slight changes in the positions of the small adjusting screws on the beam. If the amplitude is then too small for observations to be made conveniently it is increased, and after a few preliminary swings the turning-points are recorded for five or seven swings, and from these the zero is calculated. The temperature of the case is read and the barometric height is recorded.

The object to be weighed is then removed from the desiccator, wiped with a piece of silk, placed on the left-hand pan and balanced with weights. The case is then closed and left for some hours. The beam is then released and left to swing for twenty minutes in order for it to become properly fatigued, and the R.P. is determined. The weights used should be such as to give a R.P. just greater than the zero; 1 mgrm. is added, by means of the rider and the new R.P. is determined. The difference between the two values gives the sensitiveness; the temperature and barometric height are recorded. The object and the weights are then interchanged, and after waiting some time (a shorter time than in the first case is sufficient) the beam is released, fatigued for the usual time, and the R.P. determined; 1 mgrm. is added, and from the new R.P. the sensitiveness is determined. Temperature and pressure are again recorded. Finally, after the object is removed, the zero is again determined and the temperature read. If the two values or the zero differ, owing to the temperature having altered, the value at each of the temperatures at which weighings were made is calculated, and these values of the zero are used in conjunction with the R.P.'s and sensitiveness already found, to calculate the apparent weight in each pan. the two weights so obtained are corrected for errors in the weights themselves and are corrected to vacuum in the manner presently to be described; the arithmetic mean of these two weights is taken to be the true weight of the body. The time allowed for the body to remain in the case before the weighing is commenced will depend on the size and nature of the object, as has already been mentioned. In some cases better results are obtainable by balancing the object with a similar tare, and in other respects proceeding as above. Noyes in the determination of the atomic weight of hydrogen had occasion to weigh glass vessels containing the reagents under experiment. Before placing in the balance case the vessels were always wetted and then wiped dry with a clean cloth; they were then placed in the balance pan and balanced with a piece of glass apparatus of the same size and weight (in the case of hydrogen the difference of volume between the object and its tare was 0.3 cc. and in weight 2 grms.) and small weights. A stream of dried and filtered air was then passed through the case for from twelve to twenty-four hours. The air current was stopped about twenty minutes before the weighing was made. After weighing, the air current was again started and the weighing repeated after an hour. The average difference between the two weights was 0.05 mgrm., while vacuum corrections had only to be applied to the weights used and for the small difference in the volume of the object and its tare. Advantage is often taken of the absence of vibration due to trains, trams, and machinery at night and the weighings are then made.

Landolt estimates that the degree of accuracy attainable is 0.03 mgrm., while Manley places it at 0.0006 mgrm. The authors are of the opinion that the former figure is rarely attained in practice. In all cases it should be remembered that extreme accuracy in the weighing is of no value unless all the other operations involved can be carried out with accuracy of the same order; in fact, it is only in research work that any attempt to obtain accuracy to more than 0.1 mgrm. is necessary or desirable.

*From *The Chemical News*.

The Assay Balance.—These balances have a maximum load of about 2 grms., and are sometimes sensitive to 0.01 mgrm. They can therefore be used very conveniently for accurate determinations of small weights. The same principles are used in the construction of these balances as in those for heavier loads, but, since the loads are to be small, increased sensitiveness can be secured by making the parts light as far as is consistent with rigidity. Both short and long beam assay balances are made.

Micro Balances.—These instruments are intended for the determination of weights of the order of a few mgrms. only. The ordinary Nernst form is sensitive to 0.001 mgrm., while Steel and Grant describe one instrument for weighing 0.2 grm. to 0.0001 mgrm. and another for detecting changes of weight of the order of 0.000004 mgrm.

Nernst's micro-balance has a bent glass capillary tube for beam; this tube is about 30 cm. long and 0.05 cm. in diameter; it is cemented at a point one-third of its length from one end to a fine quartz thread stretched between two metal prongs. It is therefore a torsion balance; the long arm is bent down at right angles and then outwards, and terminates in a fine point which moves over a graduated scale. The pointer is bent outwards at such an angle that if produced back it would pass through the point of suspension. The short arm has a platinum hook fused on, and this carries a small platinum scale pan about 1 cm. in diameter. The weight of the scale pan is balanced by a platinum rider cemented on to the other arm. The beam is raised from the arrestment in the usual way by a cam and thumbscrew. The scale can be calibrated with known weights and small objects can be weighed by substitution. The maximum load is 2 mgrms.

In the instruments described by Steel and Grant the principle involved in weighing is as follows:—A small quantity of air (0.01 mgrm.) is sealed in a quartz bulb; if the balance case contains air of the same density as the enclosed air (*i. e.*, air at the same temperature and pressure) the apparent weight of the enclosed air will be zero, while if the pressure in the balance case be zero the apparent weight of the enclosed air will be 0.01 mgrm.; the pressure can be read to one-tenth of a mm., and can be varied from 0 to 760 mm., so that the apparent weight of the enclosed air can be varied by $\frac{1}{10} \times 0.01 \div 760$ mgrm.; *i. e.*, 1.3×10^{-6} mgrm. This reasoning assumes that the beam of the instrument is homogeneous and that the zero remains constant, conditions which are found to be obtainable. The balance is made entirely of quartz, since this material combines lightness with strength, does not corrode, has a small temperature coefficient, and is only slightly hygroscopic; it can also be obtained in a pure condition and can be readily cleaned. The beam consists of a framework of quartz rod and is about 5 cm. long, and carries two small quartz knife-edges about 1 cm. apart as its center and also a small mirror. A fixed counterpoise is attached to one end of the beam, and to the other is fused a fine quartz fibre ½ cm. long with a hook at its lower end to which is attached a short quartz rod, then a sealed -up quartz bulb, below this a quartz scale pan, and, lastly, one of a series of quartz counterpoises. In some form the scale pan, etc., are suspended by a knife-edge. The balance is contained in a small metal case with a plate-glass window in the end through which a beam of light can be thrown on the mirror and reflected back on to a scale.

The cover has a broad flange, ground to give an air tight joint when lubricated, with a corresponding flange on the base. The beam arrestment is worked by means of a cam actuated by a thumbscrew outside; the axis of the latter is ground conically to fit a tapering brass tube made air-tight by lubricating. To the side of the case is attached a manometer and a two-way tap for exhausting. In the base, by means of a ground glass joint, fits a glass tube in which hangs the scale pan, etc. In weighing the rest-point is first observed with no load on the pan and at some fixed pressure p; the weight of air in the quartz bulb is known from the volume of the bulb (determined by weighing it full of mercury), and the temperature and pressure of the air at the time of sealing it up. Suppose this pressure is P and the weight of air W; now with the load on the pan the pressure is adjusted to some value, p', which brings the beam to the same resting-point as at the first; the weight of the substance in the pan is then $\frac{W}{P}(p-p')$; *e. g.*, if the weight of air in the bulb was 0.01 mgrm. and the pressure at the time of sealing 750 mm., while the resting-point was the same with no load and a pressure of 640 mm., and with the load at a pressure of 42 mm. the load would be—

$$\frac{0.01 \times (640-42)}{750};$$

i.e., 0.00797 mgrm.

To weigh larger quantities the counterpoise below the balance pan is replaced by a lighter one of known weight (determined on the micro balance itself), and the difference of the weights of the two counterpoises at the two pressures is added to the weight determined as above.

Vacuum Corrections.—When an object is weighed in air, both the object and the weights used, owing to the buoyancy of the air, lose weight equal to the weight of the volume of air displaced; since the weight of a given volume of air depends on the temperature, pressure, and humidity the buoyancy of the air varies and therefore the apparent weight of an object will also vary from day to day. To overcome this difficulty the apparent weight of the body is corrected to what it would be *in vacuo*. Suppose the body to have a mass m and a density ρ, while the density of the air at the temperature, pressure, and humidity at the time of weighing to be δ, the volume of the body is $\frac{m}{\rho}$ cc., and this is also the volume of air displaced; this air weighs $\frac{m\delta}{\rho}$ grms., and the real weight of the body *in vacuo* is therefore $\frac{m\delta}{\rho}$ greater than its weight in air. In the same way the weights used lose weight $\frac{m\delta}{\rho 1}$ where $\rho 1$ is the density of the material used in the construction of the weights; this makes the body appear lighter than it really is, so that a correction to the apparent weight must be made by adding $\frac{m\delta}{\rho} - \frac{m\delta}{\rho 1}$; the corrected weight *in vacuo* is therefore—

$$M = m\left(1 + \frac{\delta}{\rho} - \frac{\delta}{\rho 1}\right).$$

To get an idea of the magnitude of this correction we will consider the effect of a variation of 5° C. in the temperature and 1 cm. in the height of the barometer, on the weight of an object of density near to 1. Taking the density of air to be approximately 0.0012, a variation in the temperature of 5 degrees will alter this by 1/60th, so that the change in the apparent weight of 1 cc. will be +0.00002 grm., while for 1 cm. change of pressure the apparent weight change will be 0.000016 grm.; should both changes occur so as to affect the weight in the same direction the change would be 0.000036 grm. per cc., so that in weighing to the fourth place this is not negligible for volumes of 2 cc. or more.

As already mentioned the value of δ will depend on the temperature, pressure, and humidity of the air in the balance case, and of these the humidity is not known with accuracy; Kuhn found it to be between 55 and 60. Wade and Merriman estimate it to be 50 per cent, and Brauner found it to be 35 per cent, so that the ordinary desiccating agents used give very variable results; the effect on the density of the air of a change of 10 per cent in the neighborhood of a humidity of 60 per cent is 0.000001 grm. per cc.; *i. e.*, 0.1 mgrm. on 100 cc., and the value of δ is also required to four significant figures in the same case.

Many writers, *e. g.*, Kohlrausch, suggest the use of 0.0012 for δ; this is obviously of insufficient accuracy. In order to get the vacuum correction to 0.0001 grm. in the case of an object of density about 2 and volume 100 cc. we require the value of δ to 0.000001, and therefore to know the temperature, pressure and relative humidity to a close degree of accuracy.

T° to 0.5° per cent.
P ,, 1 mm.
R.h. ,, 10 per cent.

It will be seen that the correction $m\left(\frac{\delta}{\rho} - \frac{\delta}{\rho 1}\right)$ is zero when the object and the weights have the same density, and will have the greatest value when ρ and $\rho 1$ are widely different; *e. g.*, with brass weights and objects of density 1, 2, and 3, and taking $\delta = 0.0012$ the value approximately of the correction will be:—

i. .. $m\delta(1 - \frac{1}{8}) = \frac{7}{8}m\delta = 0.001m$
ii. .. $m\delta(\frac{1}{2} - \frac{1}{8}) = \frac{3}{8}m\delta = 0.0005m.$
iii. .. $m\delta(\frac{1}{3} - \frac{1}{8}) = \frac{5}{24}m\delta = 0.0002m.$

Owing to the uncertainty of the vacuum corrections it is advisable to make them as small as possible, especially when weighing objects of large volume; the use of tares in the latter case is almost universal, the only vacuum correction then required being for the difference in volume of the object and its tare, which difference is small.

With the same object, the use of quartz weights for weighing glass apparatus has been suggested; these are practically unchangeable in the air, but are easily broken if accidentally dropped, while their cost puts them beyond the reach of most laboratories.

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Chemical Control in the Leather Industry*

A Discussion of Past and Present Aspects of this Branch of Industrial Chemistry

By David Quick Hammond

In order that the relationship of chemistry to the leather industry may be made clear, it is necessary that a brief discussion of the processes of leather manufacture first be given. At best it is possible to deal only in generalities, for each tanner has his own individual ideas and formulae which are especially adapted to the class of hides with which he deals and the use to which the finished product is to be put. Perhaps it will not be altogether out of place to speak likewise of the cordial (?) relations which have, in the past, sometimes existed between the tanner and the chemist.

The average tanner has often been, heretofore, the most incredulous of business men, due no doubt to the very secrecy with which he has attempted to keep his methods from his competitors. Tanning is a purely chemical process, despite the fact that this industry has prospered for years without any attempt being made to "chemicalize" it. Leather has long been manufactured by rule-of-thumb methods, the tanner knowing that such and such a process would bring about such and such a result without fully understanding just *why* it did. Any new methods were always discovered by trial and elimination, not by theoretical knowledge.

In a chemical process such as the tanning of leather it is impossible for any process to be practical unless it is first possible from a theoretical chemical standpoint, although a process theoretically possible is not always practical. The tanner, because of his innate skepticism, formerly refused to believe in the value of an untried process just because it happened to be evolved by a reputable chemist. He demanded an ocular demonstration that the process could be accomplished successfully in a tannery as well as in the laboratory. And because such a demonstration necessitated the risking of his own capital on what, to him, probably looked like the roseate hope of an impractical theorist, the matter usually ended there. It has been only very recently that the chemist has become recognized as essential to the tanning industry.

EARLY LACK OF MUTUAL UNDERSTANDING

Sixty-three years ago a German chemist published an article setting forth a new method for the tanning of leather, namely, by the use of potassium dichromate. At this time leather was being tanned only with barks and by methods not differing greatly from those employed by our aboriginal ancestors. It is therefore easy to see what an entirely new departure this was, but for all that, the article was given no credence, due in part, perhaps to the fact that it was couched in purely theoretical chemical terms, and likewise because the chemist admitted freely that the process had not been tried in a practical way. This was followed shortly by another article written by an English chemist describing a process for a two-bath chrome tannage which was almost identical with the chrome processes now in use. Perhaps the article went unnoticed by the tanners of the day; more probably it was lacking in cold facts when considered from a practical standpoint, and was, therefore, looked upon as a dream. Suffice it to say that it was not until nearly forty years later that the method was tried by some progressive tanner, or perhaps rediscovered, and found to be entirely successful.

It is largely due to a few of the younger and more progressive tanners, and a few chemists who realized that what can be done in a test tube cannot always be done in a factory, that the chemist and the tanner are at last in full accord. These chemists worked out the tanners' problems at the factory in a practical manner and developed systems for the chemical control of the processes. Chemistry, however, is not yet so prevalent in our tanneries as in our steel plants, our rolling mills and our munition factories, because the application of chemical control to this industry is still in its infancy.

*From the *Chemical Engineer*.

Chemists have expended their energies in bringing about definite results, but for all that, the analysis of vegetable tanning materials and oils is still made merely on a comparative basis, and possible only by the efforts of the American Leather Chemists' Association in standardizing the methods to be used.

TANNING METHODS IN GENERAL USE

Let us turn, then, to the actual methods employed. Tanning is a process which changes a perishable, putrefying hide or skin into a stable, non-putrefying article known as leather. The hide, which is in a green, salted or dried condition, as the case may be (not taking into consideration the pickled skins from Australia, etc.), must first be brought back as nearly as possible to the condition it was in directly after being removed from the animal. This is accomplished by soaking it in water for from three to five days in the case of green hides and longer in the case of the dry. The soaking should also remove all dirt, filth and salt, because their presence would interfere with a uniform action of the lime, which is applied later. Unless completely removed, the salt leaves a so-called "salt-stain" after coming in contact with the lime, and this stain could not thereafter be removed throughout the entire process.

The object of "liming," or placing the hides in vats filled with water and suspended $Ca(OH)_2$, is to eat away the outer skin surrounding the hair sacs, so that the hair may easily be removed by scraping, and to swell or "plump" the fibers of the hide so that they will be open to receive the tanning material. The liming is accomplished in four or five days, eight pounds of lime being used for every 100 pounds of hides. After the hair and flesh have been removed, the lime itself, if what is known as the "acid" process, where the tannin enters the hide in the presence of a strongly acid solution, is being employed, must also be removed, for strong acid on a hide containing lime will cause brittleness.

ACTION OF THE BATE

The lime is removed by "bateing" with hen or dog manure and wheat bran, which carries, or produces, a species of bacteria which destroy the lime. The power of these bacteria ceases automatically when all the lime has been removed, but immediately another species of bacteria, which are inactive in the presence of lime, now become active in its absence and begin to destroy the hide substance. At this point the bate must be quickly removed from the hides. There is a patent bate known as "Oropon," which is used very successfully, as it contains only the bacteria which destroy the lime, and therefore can be used without danger of any loss of hide substance. Hides which are to be tanned with a tanning solution which is only mildly acid, however, need not be bated at all, if as much of the lime as possible is first removed by washing and drumming with water.

Bateing depletes the hides, and they must again be plumped in order that the fibers may be open to receive the tanning material. This is accomplished by pickling the hides in a solution of one part by weight of concentrated 66° H_2SO_4 to 8 parts by weight of NaCl.

REACTIONS OF TWO CLASSES OF TANNAGE

The hides are now ready for the tanning material, which may be divided into two classes, vegetable and mineral tannage. Tannin, which belongs to the former class, is to be found in numerous vegetable growths such as the barks of oak, hemlock and chestnut trees, and in various plants, nuts, pods, etc., of tropical and semi-tropical varieties. Perhaps tannin is to be found most abundantly in the roots of the palmetto tree, from which source it is obtained in larger and larger percentages as we approach the equator. The tannin is leached or percolated out with water in the presence of heat and placed in contact with the hides in varying strength, according to the process used. Combination of the tannic acid with the constituents of the corium is effected, and the hide is thereby rendered tougher, less permeable and nonputrescible.

Mineral tannage consists chiefly of chrome tanning, which is accomplished by milling the hides with the solution of a mixture of potassium dicromate, HCl and NaCl, and later with sodium thiosulphate, which acts as a reducing agent and effects the precipitation of Cr_2O_3 between the fibers of the hide. This completes the tanning process, and it remains only to "finish" the leather in any manner desired.

I have given this very general description, not with the idea of presenting a detailed exposition of the actual manufacture of leather, but in order to be able to point out clearly just where the possibilities for personal research lie in the leather industry.

WIDE FIELD FOR ORIGINAL RESEARCH

Quite naturally, we turn first to chemical control. The "soaks," where the hides are soaked in water to be cleansed before entering the "limes," use running water. What kind of water brings about the desired effect most efficiently? Instantly we encounter a wide dissociation of opinion, for one tanner will say hard water; another, medium, while still another—if you can make him talk—will tell you that he has been most successful with soft water.

Next we may consider the action of the lime on the hide substance, which, of course, is composed chiefly of gelatine. How does it act? We know that it acts on the hide with the formation of ammonia; that the vigor of the reaction increases as the temperature rises, and that the formation of additional ammonia also hastens the reaction. The crude lime to be employed should be analyzed for the presence of available CaO, it being the lime in solution, of course, which acts on the hide. Although lime is less soluble in hot water than it is in cold, it is perfectly natural that the increase in the speed of the reaction attendant upon a rise in temperature should more than overbalance the loss in strength of the saturated solution of lime. The contents of the lime vats should be analyzed for the presence of ammonia, which is a check on the loss of hide substance.

In connection with the hair, which is recovered and sold as a by-product, let me say that the chemist who discovers a cheap practical method for bleaching dark hair pure white, will make a fortune, for the white hair sells for 17 cents per pound more than the dark hair. The "fleshings," from which the oil is extracted, are sold as "glue-stock," from which gelatine is made. There is ample opportunity for research here. In the matter of bate, the inventor of "Oropon" has a pretty clear field at present, but improvements will be made, no doubt, in this field also.

BOTH METHODS NEED ACCURATE CONTROL

The control of the chrome tanning process is plain analytical chemistry, although a seemingly simple analysis often produces great difficulty, for chromium is a highly refractory metal to analyse when in the presence of other minerals found in tanning liquors. In a majority of cases I have found it best to employ the volumetric method, using potassium iodide, starch paste and sodium thiosulphate, after first "popping" with sodium peroxide and neutralizing with hydrochloric acid. It is sometimes necessary to precipitate the chromium as the hydroxide with ammonia, after destroying the organic matter present with aqua regia, but often it is impossible to feel in any way certain as to the accuracy of the result because of the organic matter. Some very useful research would not be out of place with regard to this analysis, as the necessity of accurate chemical control at this point in the tanning process needs no emphasis on my part.

It is, however, the vegetable tannins which offer the widest field for research. New tanning materials are being put upon the market constantly. The chemistry of the vegetable tannin is but little understood, for its analysis is based on the amount taken out by treatment with hide powder. The analysis referred to is a comparative rather than an accurate one, much as is the case with a coal analysis, and the final result is merely a more or less accurate comparison. I believe that a far more accurate analysis is possible, and that such a one will eventually be developed. The absolute necessity of chemical control of these tanning liquors is self-evident from an efficiency standpoint alone. There are control processes now in use, but they are far from having attained an ideal state, and I believe every tannery chemist will agree that there is great room for improvement.

OIL ANALYSIS NOT TRUE GUIDE TO TANNER

Sulfonated cod oil, menhaden and mineral oils are used extensively in the tanning industry. The tanner demands various chemical specifications for the oils which he uses, but not, mark you, because the *combination* of properties written on the analysis card indicates to him the suitability of a given oil to his particular needs, but merely because he has at some time successfully used an oil having a certain property, *among the other properties listed*. Thenceforth he has associated the presence of this single property in an oil with his success, and would in future reject another oil having a *combination* of properties far better suited, perhaps, to his needs in favor of any oil whose analysis card indicated its presence. The oil analysis in general use for tanning oils is, therefore, something of a farce so far as acting as a guide in the tanner's selection of an oil is concerned; it means little to the tanner himself. There is great need for an oil analysis which will give a ratio, or some definite grading of characteristics which would show the true values of oils in their application to various kinds of leather.

Some of the larger leather concerns maintain extensive laboratories, but naturally they are not publishing the results of their costly researches. In the encouragement of her industrial chemists, America is only beginning now to do what Germany has been doing for years.

Awakened to the fact that many of them were confronting a serious predicament as a result of the war, American manufacturers bestirred themselves, looked the situation over, and then demanded petulantly why American chemists could not produce for them the dyestuffs, intermediates and a host of other materials which were obtained formerly from Germany. And the answer is: They can—if they receive in future the moral and financial backing which the German chemists have always received.

WANTED—MORE FAITH IN THE CHEMIST

It is a historical fact that the Badisch Dye Company, in Germany, spent *ten years* and *twenty millions of dollars* in practical research work before a single pound of dye was placed on the market. Would any group of American business men have sufficient faith in the American chemist to risk so much capital without being certain of the returns? Or assuming that they *were* absolutely certain of adequate returns, would American business men be content to wait so long for those returns? Most assuredly not, particularly in the past, and for this reason the American industrial chemist has thus far been outstripped by his German brother. For the future no one can answer, but there is every reason to hope for better cooperation, now that the further possibilities have been brought squarely before our financiers.

THE CHEMIST, TOO, CAN HELP

And the industrial chemists themselves have not been wholly without blame for the existing state of affairs. They must learn to school themselves still more to the idea that a new process successfully carried out in the laboratory is only half completed until they have also devised a method to demonstrate conclusively its adaptability to actual manufacturing conditions. They must learn to become, if not actually business men themselves, at least able to translate the results of their activities into business terms. American chemists are progressing rapidly along this line, and there is no doubt but that the approaching financial backing of some of our larger corporations will soon bring the American chemist second to none.

The Largest Plate Mill

A MILL for rolling steel plate that will be the largest in the world is now under construction for a Pennsylvania company. The rolls are to be 200 to 204 inches in length and will produce a finished plate 16 feet wide. It is a four-high mill, the two working rolls of chilled iron being 34 inches in diameter, the other two being 50 inches.

Large Aeroplanes

Advantages of Increased Size

MR. F. HANDLEY PAGE discussed the "Case for the Large Aeroplane" in a paper before the Aeronautical Society.

He pointed out that in general the consideration in favor of large machines is that, although the capital outlay is heavier, they are cheaper to build, maintain, and run than small ones, and thus in every type of mechanical transport progress is seen towards the employment of larger and larger machines with the object of taking full advantage of the economies effected. In an aeroplane, however, there could be no advantage in the use of large machines if the increase in size gave a disproportionate increase in weight which would more than nullify the constructional advantages, or if the large aeroplane had aerodynamical disadvantages.

SIZE AND WEIGHT

In examining the rate at which weight increases with increase in size, he omitted the weight of the power unit, comprising engine, tanks and fuel, as well as of the useful load, and confined his argument to the machine structure—that is, the portion which supports the load, whether on the ground or in the air, with the necessary directing surfaces and their attachment to the main portion of the aeroplane. He pointed out that as a machine is made smaller a limit is eventually reached beyond which it is not possible to decrease the thickness of the material and retain adequate local strength. This is especially the case in aeroplane work, in which the members are usually stressed as struts and for which, therefore, a hollow tubular construction is the most efficient form from the point of view of minimum strength for a given weight. In making tubular members, whether plane spars, fuselage, struts, or longerons, it is not advisable to decrease the thickness of the walls below five-sixteenths to one-fourth inches, and even this is on the small side when allowance is made for errors in workmanship and the fitting in of the necessary tongue piece to make a secure joint. Here considerable economies can be effected in weight with increase in size. Local strength also determines the construction of subsidiary parts such as tail skid, ribs, and tail planes, and does not need to be increased with increase in the size of the machine. Here again weight economy is possible.

This better utilization of material more than offsets the increase in weight that would occur in the planes provided they were increased in a geometrically similar manner and the loading aspect ratio kept the same. The fuselage weight also is considerably decreased, the chassis weight remaining about the same.

SIZE AND PERFORMANCE

The author next made a general comparison between aeroplanes of different sizes on the basis of a new method of aerodynamical comparison explained earlier in the paper, the total weight of the machine being modified in accordance with its size in the light of the conclusions reached as regards the effect of increase in size on structural weight. The general conclusion drawn from this theoretical consideration of the aerodynamical and structural qualities of the large machine was that for the same total weight carried per horse-power it will effect the better performance.

THE PILOT'S STANDPOINT

Large aeroplanes can be built to operate quite as easily and to fly with as little fatigue as the best of the small ones. Servo-motors are not required for the controls provided the controlling surfaces are properly balanced. Wind gusts which seem large to a small machine being relatively small in their effect on a large one, there is less work in flying the latter, and it will plough its way through gusts without any control being necessary, whereas a good deal of warping might be needed on a small one. The large machine can also be handled more easily on the ground and can alight in smaller areas.

From the point of view of load carrying or long distance flying the large machine has it all its own way. For future commercial development it scores with plenty of room for passengers and luggage or mails. The one thing the aeroplane requires in order that it may take its proper place in commercial work is certainty in operation. Engines will probably be more heavily built to reduce the possibility of breakdown, and multi-engine machines will be used which will fly satisfactorily even if one engine is disabled. This again points to the larger machine.—*London Times Engineering Supplement.*

Indian Indigo Industry

IT is announced that the government of India has engaged the services of an expert to study indigo production with a view of devising means of standardizing the natural product in a form which will enable it to compete with the German synthetic dye, says the *London Chamber of Commerce Journal*. If this is done, and if the planters adopt some coöperative system of manufacture and marketing, the industry may be placed on a sound basis for the future. Much useful work on indigo has been done in the past year or two at the Agricultural Research Institute at Pusa. The Java indigo plant was introduced in 1898 by a Bihar planter and has now replaced the old variety on almost every plantation. By selection it is hoped to get a superior type of plant with a large yield of leaf, and probably also a larger yield of finished indigo. It is believed that the so-called wilt disease in indigo plants is to be attributed mainly to bad cultivation and water logging of the soil, and that it can be avoided by drainage on a special system and surface cultivation to ensure proper aeration of the soil. A new variety of wheat called "Pusa 4" has been introduced, which can be grown as a cover crop for Java indigo on high lands and enables the cost of cultivation to be reduced. The preliminary results obtained indicate the possibility of again establishing the crop on a firm basis, and of natural indigo competing successfully with the synthetic dye. The rise in the price of natural indigo to five times the pre-war figure has had the effect of encouraging the expansion of the indigo area in Bihar. The exports of natural indigo from India last year were 2,097 (long) tons, valued at £1,385,795 as compared with 547 tons, value £141,938 in the pre-war year 1913.

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